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AERONAUTICAL PRACTICE

PART II

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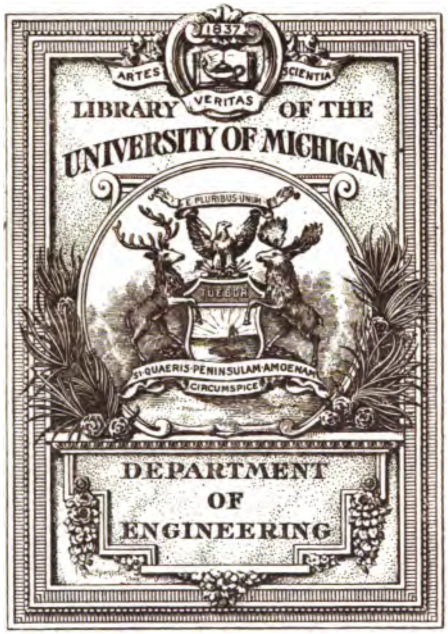

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AERONAUTICAL PRACTICE

PART II

INSTRUCTION PAPER

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AERONAUTICAL PRACTICE

PART II

LEGAL STATUS OF THE ART

Wright Patents in American and Foreign Courts. Probably no single phase of aviation is as little known by those who should be well informed on the subject as the actual status of aviation where the Wright patent is concerned. The move on the part of the Wright Brothers to establish the standing of their patents by having them adjudicated and, as this is an extremely lengthy process, to restrain infringers in the meantime, has led to a perfect flood of criticism—even abuse and vilification—all of which has been misguided, to say the least.

A clear understanding of the situation as it now stands may be obtained from the following brief resumé of the events that led up to this attitude. nI December, 1903, the Wright Brothers first succeeded in flying a motor-driven heavier-than-air machine guided by man. The adoption of the wing-warping device used in connection with the operation of the vertical or direction rudder of the machine, which made this possible, marked the culmination of centuries of effort bent upon the same goal, and which in the twenty years just preceding had engaged the talents of many of the world's noted scientists. It must be conceded by even their most bitter antagonists that they were the first to actually fly; moreover, that although others may have suggested or even attempted to use a device similar to theirs, they were the first to perfect it, and that the state to which they developed it made the general introduction of flying possible. To refuse to admit this is merely going contrary to the facts. It must be further conceded that they were the first to obtain patents on a device of this nature which had actually proved operative. The importance of this will be pointed out later.

There is accordingly presented on the one hand a patentee who, after years of labor and the expenditure of a considerable sum of

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money, has succeeded in inventing a device of an absolutely revolutionary nature; on the other hand, an enormous number of investigators in the same field who wish to avail themselves of his hard-earned success without in any way contributing to the reward which should be his. The United States courts held that Alexander Graham Bell was the first to perfect a device for the transmission of speech over a wire. A situation analogous to that now presented in the field of aviation would have arisen, had the public claimed the right to help itself to Bell's telephone thirty years ago. But a telephone could not be manufactured, bought, or sold, for love or money, except by the Bell Telephone Company, up to March, 1893—the date the patent expired. The restriction of a utility of such far-reaching importance could be criticized as an unjust monopoly, and undoubtedly the lack of competition retarded the development of the art, as was shown by the strides it made when the bars were let down, but there was no possible legal basis for complaint.

There appears to be little doubt but that the Wright patent is quite as basic as that of the telephone. Speaking over a wire was generally considered quite as much of an impossibility before Bell's invention, as flying was before that of the Wright invention. Whether the Wright Brothers decide to grant licenses to manufacture on a royalty basis, once their patent has been successfully adjudicated, is entirely for them to decide. Their non-committal attitude on the question in the meantime, despite the precedent of the Selden automobile patent under which numerous licenses to manufacture were granted pending its ligitation, has led to a great deal of criticism with "hampering the development of the art" as its chief foundation. But there is quite another side to the question. It has been shown to be possible to fly without utilizing the Wright device, as in the original Voisin biplane, but not with any great degree of speed or safety; or again, as in the case of the Pfitzner monoplane, the possibilities of which have not been fully put to the test as yet. The necessity of competing against the patented device should be instrumental in advancing the art, instead of hampering its development. It is scarcely necessary to add, that these inventors, unless of a sufficiently philanthropic turn of mind to dedicate their inventions to the public, would likewise expect to reap the reward of their efforts. It is simply a case of the survival of the fittest, and should the Wright Brothers' invention prove to be the only successful method of flight, as it has proved thus far—when it is considered that all successful machines to date either warp the planes or employ a method which is claimed to infringe this—there appears to be no reason why they should not legally control the situation. Their attitude toward the matter, as noted by an unbiased observer who has probably had a better opportunity to appreciate the status of affairs as they really exist, leads to the belief that the upholding of their patent rights will not bring into existence any restrictive monopoly. This has already been amply demonstrated by their full permission for the employment of their device in experimental work.

What they have attempted to stop has been merely the manufacture of machines alleged to infringe their patents for sale and exhibition purposes—in other words, the making of money by means claimed to have been made possible through the utilization of their ideas, whether in the same or a modified form. In brief, the legal steps taken thus far are as follows:

The patent which embodies the Wright flying machine was issued May 22, 1905. In the latter part of 1909, the United States Circuit Court was appealed to to enjoin the Herring-Curtiss Company and Glenn H. Curtiss from manufacturing, selling, or using for exhibition purposes, the Curtiss aeroplane. Contrary to established precedent in patent litigation, Judge Hazel, of the United States Circuit Court in Buffalo, granted a preliminary injunction restraining the defendants mentioned. The chief question at issue in this instance was whether or not movable auxiliary surfaces, popularly termed ailerons, or wing tips, constituted an infringement of the Wright patent. The court reviewed the Wright patent at some length, but in its opinion the question of infringement as between warping and the use of ailerons is the only one of importance existing at present. On this, Judge Hazel said:

> Defendants claim generally that the difference in construction of their apparatus causes the equilibrium, or lateral balance, to be maintained and its aerial movement secured upon an entirely different principle from that of complainant; that defendants' aeroplanes are curves firmly attached to the stanchions and hence are incapable of turning or twisting in any direction; that the supplementary planes or so-called rudders are secured to the forward stanchion at the extreme lateral ends of the planes and are adjusted midway between the upper and lower planes with their margins extending beyond the

edges; that in moving the supplementary planes equal and uniform angles of incidence are presented as distinguished from fluctuating angles of incidence, which claimed functional effects, however, are strongly contradicted by the expert witness for complainant. Upon this contention, it is sufficient to say that the complainant's affidavits so clearly define the principle of operation of the flying machine in question that I am reasonably satisfied there is a variableness of the angle of incidence in the machine of defendants which is produced when a supplementary plane on one side is tilted or raised, and the other simultaneously tipped or lowered. I am also satisfied that the rear rudder is turned by the operator to the side having the least angle of incidence and that such turning is done at the time the supplementary planes are raised or depressed to prevent tilting or upsetting the machine.

On the papers presented, I incline to the view, as already indicated, that the claims of the patent in suit should be broadly construed; and when given such construction, the elements of the Wright machine are found in defendants' machine performing the same functional result. There are dissimilarities in the defendants' structure—changes of form and strengthening of parts—which may be improvements, but such dissimilarities seem to me to have no bearing upon the means adopted to preserve the equilibrium, which means are the equivalent of the claims in suit and attain an identical result.

Defendants further contend that the curved or arched surfaces of the Wright aeroplanes in commercial use are departures from the patent which describes "substantially flat surfaces," and that such a construction would be wholly impracticable. The drawing attached to the specification, however, shows a curved line inward of the aeroplane with straight lateral edges, and considering such drawing with the terminology of the specification, the slight arching of the surface is not thought a material departure. At any rate, the patent in issue does not belong to the class of patents which requires narrowing to the details of construction.

The preliminary injunction restraining Curtiss was accordingly granted January 3, 1910. About the same time the United States Circuit Court for the Southern District of New York was appealed to to restrain Louis Paulhan, the French aviator, from using a machine, claimed to infringe the Wright patents, for exhibition purposes in this country. Paulhan contended that it would be suicidal to interconnect the operating control of the ailerons and the direction rudder; that either may be and is used independently of the other; that the use of the rudder alone will prevent "skidding" and restore the aeroplane's equilibrium; and that complete turns may be made without employing the ailerons or warping the wings. An excerpt from Paulhan's statement on this point is as follows:

In turning a corner in the Farman biplane, or any aeroplane with which I am familiar, it is not at all essential to use the aileron to increase the angle of incidence on the outer edge. There are circumstances in making a turn in

> such machines and in straightaway flight when the operator would use the aileron or warp the wings without turning the rudder at all, and very often the rear vertical rudders are used without any interference with the ailerons.*
>
> If for some reason such aeroplanes move obliquely to their longitudinal axis, *i.e.*, "skid," the use of the rudder alone will correct the aeroplane's equilibrium and bring it back to its normal line of advance. The operator can make a complete turn by the use of the rear vertical rudders alone and without using either ailerons or warping to correct horizontal equilibrium. The rear vertical rudders have a most powerful turning effect in all cases. In making a sharp turn the outer end of the aeroplane may be tilted up and a new plane of movement established which may be at an angle of ten or more degrees. The tendency of the rudder during such movement is to swing the tail to the outer side of the turning arc with great rapidity. Where one side of the Farman biplane is depressed or tilted downward, that side tends to move more slowly and the aeroplane turns in the direction of the depressed side.

These statements represent a condition so utterly contrary to what the Wright Brothers had experienced in all their experiments as absolutely essential to flight, that they invited Paulhan to substantiate his theories in flight in their presence, making his ailerons fast so that they could not be moved. It is believed that some of these test flights were actually carried out, but what their result was does not appear. At any rate, Judge Hand granted a preliminary injunction to the Wright Brothers against Paulhan on February 17, 1910, requiring the defendant to file a bond for $25,000 for one month's flights. This was shortly afterward changed to $6,000 a week.

The most significant part of Judge Hand's opinion, which was lengthy, throws considerable light on what he considered the invention to consist of, and also illustrates what is regarded as the status of the numerous prior patents which are claimed to anticipate the Wrights'. After referring to the Ader machine in which there was a provision for warping the planes, he says:

> The mere coincidence of these parts by chance or as a matter of taste was in no sense an anticipation of their functional correlation, in understanding which the complainant's discovery consists and with it their invention.

In fact, the Wright Brothers state in their application:

> We are aware that, prior to our invention, flying machines were constructed having superposed wings in combination with horizontal and vertical rudders.

---

*Provision is made in the Wright machine for independent use of either warping or vertical rudder, as the controlling lever may be moved in one or both directions at will.—Ed.

Some of the more important patents upon which the claim of anticipation is based are the Mattullath patent, application filed January 8, 1900; the Boswell patent dated September 24, 1901; and the machines of Mouillard, Le Bris, and Ader, discussed in Chanute's "Progress of Flying Machines."

At a time when the controversy is at its height, it is naturally difficult to reconcile the innumerable conflicting statements and the maze of contradictions that exist. Where what is known as the "prior art" is concerned, however, it would appear quite probable from a statement occurring in an opinion handed down by the United States Circuit Court of Appeals in New York, that earlier patents will be disregarded where they have not been shown to be operative, which would naturally exclude practically every patent granted prior to May 22, 1906. The action in question was in regard to a railway signal, the reference in the opinion being by way of illustration of the principle that a patent for a useful device will not be held void because of an earlier patent for a useless device.

> Success can not be anticipated by failure. When the problem of aerial navigation is finally solved by the construction of a secure, dirigible airship, it is safe to predict that the inventor's patent will not be invalidated by a prior structure, no matter how perfect it may be, which was never known to fly.

As already mentioned, it was quite contrary to precedent to grant a preliminary injunction restraining an alleged infringer before the patent was actually adjudicated, *i.e.*, upheld in an action to test its validity, so that in vacating the injunctions against Curtiss and Paulhan about six months later, the Circuit Court of Appeals simply followed the long-established precedent of American patent law. As a general rule, preliminary injunctions are not countenanced in patent cases, even by the lower courts. It seems evident upon reading in full the opinions of the lower courts in this case, and particularly that of Judge Hazel, that the court was led to disregard precedent through what appeared to be the clearness of the case of infringement of a basic patent of far-reaching importance.

The reason why preliminary injunctions are so rarely issued is because seldom, indeed, is infringement so clearly established that a court is justified in restraining the use and manufacture of an invention before the question of patent validity is decided. The hardship which results from too great a readiness on the part of a lower court to restrain an alleged infringer is strikingly illustrated by the injunctions issued against Curtiss and Paulhan. As a result, the Wright Brothers controlled aviation in this country (*i. e.*, exhibition flights, manufacture, and sale of machines) absolutely for half a year. Unless he filed a bond with the court, no aviator, using a machine equipped with ailerons or wing-warping devices operated in conjunction with a vertical rudder, could make, sell, or fly his apparatus in the United States.

But that there appeared to be excellent reason for departing from established precedent in this instance must be plain to anyone who has had an opportunity to review the correspondence that passed between Curtiss and the Wright Brothers prior to the time that Curtiss began to build or exhibit machines for profit. Curtiss was assisted to a considerable extent in the design and construction of his machine by the Wrights, and acknowledges his indebtedness to them for information of this nature as well as for valuable data. When it was rumored that Curtiss was about to enter the commercial field, the Wright Brothers voluntarily offered to take up the question of a license to use their machines, but Curtiss replied under date of July 24, 1908, that, contrary to newspaper reports, he did not expect to do anything in the way of exhibitions. This correspondence was all placed in evidence in support of the petition for the injunction, and it was further shown that Bleriot did not apply anything in the nature of the present method of control until subsequent to the publication of the French Wright patent in 1904. In fact, Captain Ferber, who is regarded as the leading French authority on aviation, states in his works that the art was only taken up in France as the result of the publication of the Wright Brothers' early experiments in Europe. There has seldom been a case in patent litigation where infringement of a sound basic patent was apparently so clearly made out, so that it was difficult to see how the court could refuse to grant the injunction under the circumstances.

The vacating of these injunctions accordingly forms no criterion of the final outcome, as no trial on its merits has yet been held. The Circuit Court of Appeals merely held that infringement was not so clearly established as to justify a preliminary injunction. A trial of the action against the Herring-Curtiss Company for infringement was therefore begun, and other similar actions have since been instituted, notably that against Claude Grahame White, the English aviator. When this action comes to trial, Henri Farman promises to produce several heretofore unknown foreign patents which he has acquired and which are claimed to clearly anticipate the Wrights'. Meanwhile the Farman Brothers are threatening to prosecute all infringers of the several patents they hold in common. In view of the opinion of the Circuit Court of Appeals cited above, Farman's patents would not appear to be of any great value as evidence in this country, as they naturally do not cover a machine that actually flew before that of the Wright Brothers. The German Wright patent has recently been upheld in part, although the basic feature in regard to the simultaneous action of the rudder and wing flexing has been invalidated.

Under the laws of Germany and France, a disclosure of an invention by the inventors, or by anyone else who has knowledge of it, before the application for a patent is filed, is sufficient to render the patent void. Such disclosure must be sufficient to enable anyone to understand how to build and use the invention. The revelation of the invention upon which the German patent office based this decision were citations from *L'Aeronaut*, Paris, April, 1903, giving a report of the address of Chanute describing the Wright experiments at Kitty Hawk in 1902, and from *Automotor*, London, February 15, 1902, giving a synopsis of the address of Wilbur Wright before the Western Society of Engineers in 1901, describing their experiments of that year. The statement of Chanute which is cited as a disclosure of the Wright invention was as follows:

"To assure transverse equilibrium, the operator works two cords, which warp the right and left wings and at the same time adjust the vertical rear rudder."

The German Patent Office has taken the extreme position that these few words were sufficient to teach anyone how to build and operate a flying machine in 1903, and that they canceled the right of the inventors to any property in their invention in Germany. The Wright Brothers do not believe that this decision is based upon a proper interpretation of the law and have appealed to a higher tribunal, as noted. From the report of the French decision given further along, it will be apparent that the French court took a far more liberal view of this aspect of the case. The court upheld two specific forms of patent, combining the steering and flexing. In Germany, patent procedure is the reverse of what it is here—a patent is presumed to be valid from its date of issue until proved to the contrary. Accordingly, five German firms formed a syndicate and brought suit to have the Wright patent declared of no value, with the result mentioned. This decision is by the Patent Office and judgment is open to appeal before the Imperial Supreme Court at Leipzig, action to this effect having been taken.

In France, Le Compagnie Generale de Navigation Aerienne, the sole French concessionaires of the Wright patents, brought actions against more than half a dozen prominent manufacturers and inventors, such as Bleriot, Farman, Antoinette, Clement-Bayard, Esnault-Pelterie, Santos-Dumont, and others. Santos-Dumont alone withdrew all defense, and, curiously enough, he is the only defendant in whose favor judgment was rendered, on the ground that his was the only aeroplane that was not built for purposes of trade or private gain.

The types of aeroplanes involved were the Antoinette and Bleriot monoplanes with warping wings, the Farman with ailerons or "flaps" at the rear lateral margins of the planes, and the Hautier-Vendome with ailerons at the front edges of the wings. A large part of the decision relates to matters of French law which renders patents invalid under certain conditions, such as failure to work an invention within three years of the time of applying for a patent, and the revelation of an invention before patenting it. The decision was in favor of the plaintiffs in all of the cases except that of Santos-Dumont, as mentioned, but before rendering final judgment, the court gave the defendants a final loophole through which to crawl, if possible, by appointing a committee consisting of M. Léauté, Major Paul Renard, and Marcel Deprez, to determine whether the Wright patent of March 22, 1904, had not been anticipated by some machine unknown to the defendants at the time of the trial. The court said in part:

> If the action in pursuit of a claim is established in principle, it is subordinated to the double question of knowing if there has not been one or more priorities of all the parts opposed to the patent of 1904, and if, on the other hand, it will not be found void as against certain of the defendants, as they may have made an entirely new adaptation of the mechanical means pointed out by the Wrights for the re-establishment of the lateral equilibrium, and of which they shall have conceived a structural means constituting in connection with the patented invention an invention entirely new and original.

But on this point, a writer in the official organ of the Aero Club of France, which completely controls aviation in that country, says:

> The mission given to the experts is singularly limited, and does not allow the defendants any hope of emerging victorious from the contest. So one should not be astonished that many of the defendants already express an intention of appealing from a judgment which they consider so disastrous to them.

In the trial of the action the plaintiffs alleged that the Wright patent, being their personal property, gives them the right to claim not only the joint and separate action of the mechanism of the rear direction rudder and the variation of the angles of incidence (to wit, the combination), but separately, each of the elements of this combination in so far as it is employed for the result provided for, that is, for the re-establishment of the lateral equilibrium and the maintenance of the direction of flight. Wilbur Wright was present and testified in person.

The main points of defense presented were: That the Wright patent was not valid because (1) the Wrights had revealed their invention before applying for a patent; (2) they had not worked the invention within three years; (3) the invention was known to the prior art. Further, that the defendants did not infringe the patent, which gives the plaintiffs only the property of the combination employed, and not the distinct elements which are employed separately and independently for the same purpose, elements which they claim are public property.

The claims of forfeiture were rejected by the court, the substance of the decision, stripped of its Gallic verbiage, being as follows:

(1) That the subject of the Wright patent of March 22, 1904, was patentable.

(2) That it was impossible to keep an invention of this nature entirely secret, and the photographs and descriptions published were not sufficient to invalidate it.

(3) That the Wrights were the first to fly, some of the defendants having claimed that flights had been made in France in 1898, and that they had invented the system of control that makes flight possible.

(4) That the patent had been worked in France as soon as possible under the circumstances.

(5) That the patent was valid.

(6) That the independent operation of the wings and rudder as used by the French was not sufficiently claimed in the Wright patent, and that, therefore, the French machines were not infringements of the latter. (This is apparently a "joker" that entirely offsets any value the decision might otherwise have, but this part of the decision is that of a "substitute judge," a technical expert whose services are required by the French law to advise the courton technical matters, and it was subsequently overruled by the court itself.)

The court, composed of three judges, confirmed the above findings with the exception of No. 6, on which point it stated that:

> While the independent operation of the wings and rudder was not specifically claimed in the words of the patent, yet the independent operation of the parts could not be considered as a new invention, but simply as an improvement in detail of the original invention, and that the patentees of the original invention were entitled to the benefits to be derived from it.

By referring to the descriptions of standard machines it will be noted that none of the French defendants were makers of a type in which the ailerons or controllable stabilizing devices were entirely separated from the main supporting planes, as is the case in the Curtiss, in which the ailerons are placed between the main surfaces of the biplane. All the French makers built infringing types of monoplanes, with the exception of Farman. This is practically the sole point upon which the entire Wright vs. Curtiss action hinges, and in view of the fact that it seems probable the United States Court will extend the construction of the patent to cover the use of separate ailerons as being an application of the same principle, the following resumé of the opinion of the French court is both valuable and instructive:

> Considering the point once established that the separation of the two elements claimed is a type of improvement, this separation ought to be considered as an appurtenance of the patent of 1904, that the improvement is a natural development of the primitive invention from which it can not be separated, and that proceeding from the master idea which is the generator of it, the patentees should have the right to profit by it. Of what little importance, then, is it, that in 1907 the Wright Brothers took out two other patents in which the independence of the warping and of the directing rudder was expressly provided, except that the combination of the two elements could be, if desired, effected by the hand; admitting that these two patents of 1907 repeat in certain parts the things which can be found in the patent of 1904 and that even these improvements in detail which were then meant to be patented were without importance, they would not have in them, to say the least, any utility as patents of extension.

It will be noted that the Court reversed the opinion of the "substitute" on the only point which he found in favor of the defendants. In reversing this point, that the independent operation of the wings and rudder circumvented the patent, the Court said:

> In the patent of 1904 the connection of the warping device with the rudder is so minutely described that it can be understood and applied by engineers and constructors of aeroplanes; there is no reason to believe that the Wright Brothers should have made a more general claim and should have claimed each of the elements, taken separately, but they should be confined to the limits which they have described in the patent.
>
> After the patent of 1904 the invention consisted in a method of maintaining or re-establishing the equilibrium of the aeronautic apparatus and of guiding the machine in a vertical or horizontal direction. Among other elements the patent provides (1) the existence of two horizontal surfaces or wings, consisting of a frame on which fabric is spread, and connected one to the other by means of posts and articulations, which permit of movements of torsion and flection of the ends of the wings in opposite directions; (2) of a vertical rear rudder, connected to the cables that produce the torsion of the ends of the wings.
>
> The combination of the two elements is well within the scope of the patent. It says in lines 14 to 19, page 3:
>
> *By this means of attachment the same movement of the cables which actuates the ends of the wings, also presents to the wind that side of the vertical rudder which is turned toward the end having the smaller angle of incidence.*
>
> In vain the suing company cites two other passages of the description. The passage from the 34th line to the 43rd line of the third page does not say that the rudder can be independent; nor is the passage from the 45th line to the 57th line more explicit:
>
> *This invention is not limited to the construction and attachment of the rear rudder herein described, nor to this particular construction of surfaces or wings, for one can employ this combination in the use of any movable rear rudder operated in conjunction with any wings capable of being presented at different angles of incidence at their opposite ends, for the purpose of restoring the lateral balance of a flying machine and of guiding the machine to right or left.*
>
> The words "actuate at the same time," about which so much has been argued, can be interpreted only in the sense that there is a device which permits of the movement of the two commands at the same time. This point once established, the disassociation of the elements claimed is a type of improvement.
>
> This disassociation must in principle be considered as a dependent of the patent of 1904, since this improvement is a natural development of the primitive invention, proceeding from the master idea in which it had its origin, and from which it can not be separated. The patentees alone have the right to profit by it.

The outcome in this country appears to depend entirely upon whether ailerons or wing tips—independent auxiliary surfaces between the planes, as in the Curtiss, or hinged extensions of the wings themselves, as in the Farman—really constitute an infringement on the principle of actually warping the surfaces of the wings themselves. This may be gathered from the following concise statement of claims 1, 2, 3, 4, and 7 of the Wright patent. The specifications are drawn to cover monoplanes, biplanes, and machines having two or more superposed surfaces.

> 1. In a flying machine, a normally flat aeroplane having lateral marginal portions capable of movement to different positions above or below the normal plane of the body of the aeroplane, such movement being about an axis transverse to the line of flight, whereby said lateral marginal portions may be moved to different angles relatively to the normal plane of the body of the aeroplane, so as to present to the atmosphere different angles of incidence, and means for so moving said lateral marginal portions, substantially as described.
>
> 2. The application of vertical struts near the ends and having flexible joints.
>
> 3. Means for simultaneously imparting such movement to said lateral portions to different angles relatively to each other.
>
> 4. Refers to the movement of the lateral portions on the same side to the same angle.
>
> 7. Means for simultaneously moving vertical rudder so as to present to the wind that side thereof nearest to the side of the aeroplane having the smallest angle of incidence.

As will be noted in the opinion of Judge Hazel, the Wright patent will undoubtedly be construed broadly and not narrowed down to constructional detail so that the reference to "flat planes," of which much was made in the briefs of Curtiss and Paulhan in their defense of the injunction proceedings, will probably not affect the decision in itself. Both defendants strongly contended that a machine with flat planes would be entirely impracticable, *i.e.*, an inoperative device, thus maintaining that the present Wright machine is not the apparatus described in their patent. This is a point of the greatest importance and has been the means of declaring patents invalid that would otherwise have been of considerable value, such as the patent on clincher tires for automobiles. Some of the more recent high-speed racing machines built in France during 1911 have been equipped with supporting surfaces that are almost flat or at least sufficiently so to substantially fulfill the requirements of this claim of the patent under the broad construction accorded it.

This accordingly confines the points at issue to whether supplementary surfaces, either independent of or attached to the wings themselves, constitute an infringement of the warping device of the Wrights, and whether the simultaneous operation of the vertical rudder in conjunction with these supplementary surfaces, regardless of how it may be carried out, is an infringement of the functional correlation of these parts which Judge Hand states constitutes the invention of the Wright Brothers.

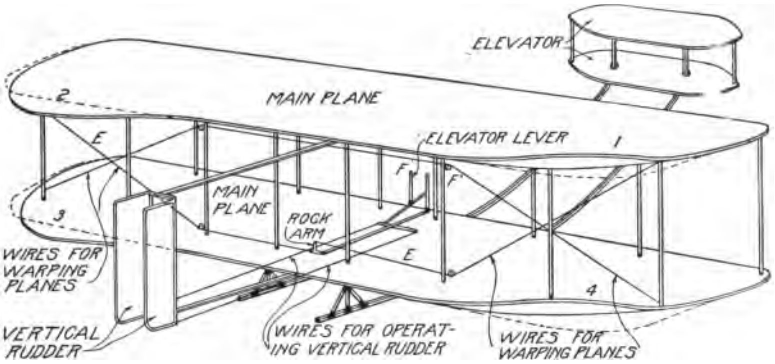

Fig. 40. Diagram of Wright Control System, Showing Warping of Main Planes

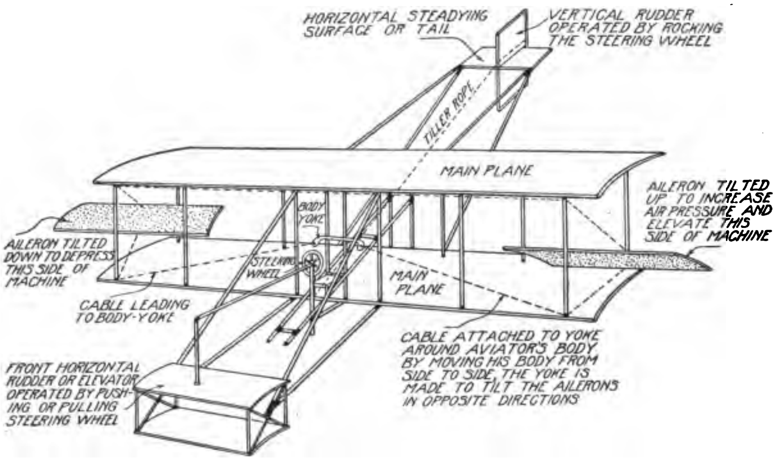
HORIZONTAL STEADYING SURFACE OR TAIL
VERTICAL RUDDER OPERATED BY ROCKING THE STEERING WHEEL
TILLER ROPE
MAIN PLANE
AILERON TILTED UP TO INCREASE AIR PRESSURE AND ELEVATE THIS SIDE OF MACHINE
BODY YOKE
AILERON TILTED DOWN TO DEPRESS THIS SIDE OF MACHINE
STEERING WHEEL
MAIN PLANE
CABLE LEADING TO BODY-YOKE
CABLE ATTACHED TO YOKE AROUND AVIATOR'S BODY BY MOVING HIS BODY FROM SIDE TO SIDE THE YOKE IS MADE TO TILT THE AILERONS IN OPPOSITE DIRECTIONS
FRONT HORIZONTAL RUDDER OR ELEVATOR OPERATED BY PUSHING OR PULLING STEERING WHEEL

Fig. 41. Diagram of Curtiss Control System, Showing Use of Ailerons Swung between Main Planes

As shown by the drawing, Fig. 40, the Wright machine is provided with means for operating the vertical rudder in conjunction with the warping of the main planes, as covered by claim 7 of the patent. Ability to move the hinged lever on the machines in actual use in two directions makes it possible to use either control independently or both simultaneously.

Fig. 41 shows that these controls are separate in the Curtiss machine, but they naturally can be employed simultaneously by the aviator. The Farman system of control is shown in Fig. 42, and the Bleriot in Fig. 43. The Wrights regard it as basic that both controls be carried out together to attain successful flight, Wilbur Wright explaining the operation of turning as follows:

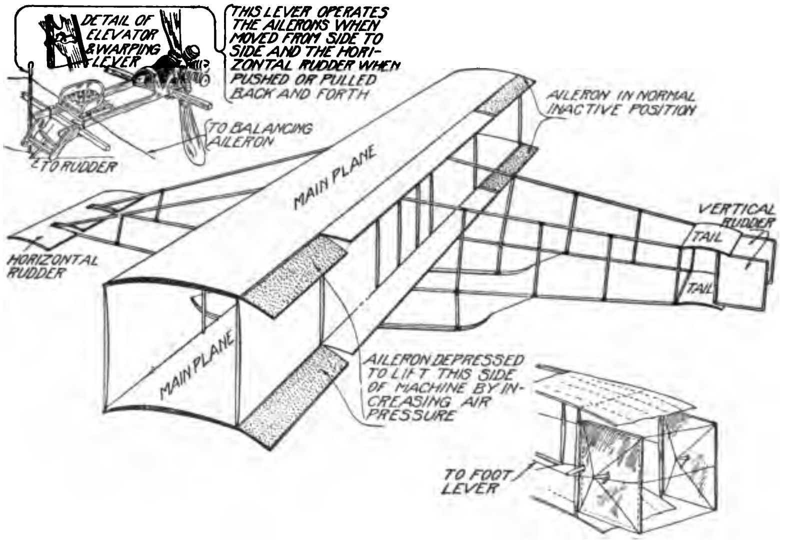
DETAIL OF ELEVATOR & WARPING LEVER
THIS LEVER OPERATES THE AILERONS WHEN MOVED FROM SIDE TO SIDE AND THE HORIZONTAL RUDDER WHEN PUSHED OR PULLED BACK AND FORTH
TO BALANCING AILERON
TO RUDDER
MAIN PLANE
AILERON IN NORMAL INACTIVE POSITION
VERTICAL RUDDER
TAIL
TAIL
HORIZONTAL RUDDER
MAIN PLANE
AILERON DEPRESSED TO LIFT THIS SIDE OF MACHINE BY INCREASING AIR PRESSURE
TO FOOT LEVER

Fig. 42. Farman System of Control, Showing Use of Ailerons Attached to Main Planes

> In making a turn to the left, the left side of the machine would slow up and the right side would move faster. If only the vertical rudder were employed to make the turn, the machine would skid greatly to the right, headway would be lost and, at this point in the turn, the machine would tend to stand on its right side, lose support, and drop. To make a short turn to the left without losing headway, the practice is to warp the right-hand end of the plane down and the left-hand end up, with vertical rudder turned to the left, it being necessary to heel the machine to the left to prevent skidding.

It is claimed to be possible to make turns of great radius without warping the wings, but the machine would skid more or less and, moreover, would not be entirely safe. Its stability would be precarious. In making a short turn without the use of the vertical rudder in conjunction with the warping of the wing ends, the machine tends to turn on a vertical axis like a corkscrew, and the simultaneous operation of both essentials is necessary to overcome this.

In view of the flatly contradictory statements made in the briefs submitted in the injunction proceedings, the frank opinion of Louis Bleriot, France's foremost aeroplane designer and builder, contained in a letter written regarding the granting of the injunction against Paulhan gives an inkling of what the views of other unprejudiced inventors in the field really are:

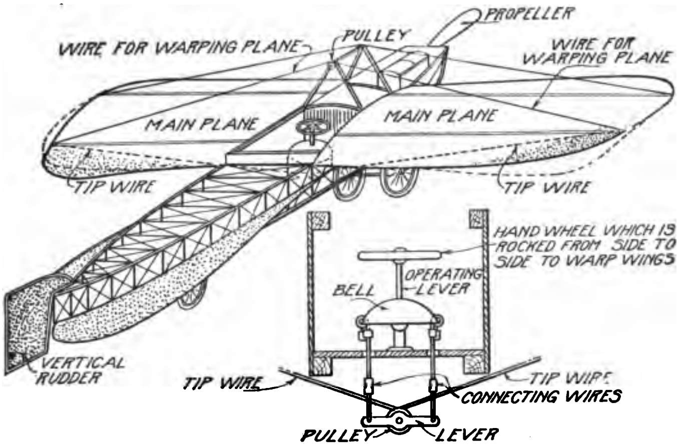

Fig. 43. Bleriot Control System by Warping of Main Plane

> Concerning the Wright patents my opinion is that the warping of the wings, taken in itself, is public property, and I think this can easily be shown. The vertical rudder is itself public property and it is only the combining of these two effects—balancing and steering—in a single lever control which can with some show of reason be claimed by the Wright Brothers. I have personal reason to regret that they did not confine their claim to this single lever, for it is an interesting improvement and one concerning which we could have established an understanding with the Wrights that would have been of profit to all aviators.
>
> In all my present French machines, the warping of the monoplane surface is brought about with the left hand, while the steering is dependent on

foot control. These two effects are entirely independent and in no way necessarily corrective, as called for in the Wright patents; on the contrary, experience shows that the major part of the time their effects should be added to each other instead of being corrective of each other. *This independence of control necessitates a somewhat more delicate hand and a longer apprenticeship*, but one which the present uncompromising attitude of the Wrights forces me to maintain.*

I have gone further: In view of their threats I have tried to do away completely with warping, using only for balancing purposes a somewhat larger vertical keel.† The result was entirely satisfactory: I was in this manner able to fly without warping, in winds as strong as those faced by the Wrights. I delivered to Paulhan two such machines for his American trip and, in his trials at Pau prior to leaving France, he flew perfectly without any warping device. He made as sharp turns as previously and merely had to use a greater tilt when doing so.

To sum up: This question of warping about which so much fuss has been made, and which seemed to be a *sine qua non* condition of lateral stability, proves to be of far less importance. If warping renders signal service in keelless machines of wide wing area such as the Wright machines, it becomes a far less necessary improvement in machines of small breadth of wing, provided with keels, and is entirely needless in machines with vertical partitions, such as the Voisin biplanes. As aeroplanes will tend more and more toward increasing speed and diminution of breadth of wing, the question of warping will more and more lose its importance.

I merely wish to say that it was regrettable to see at the dawn of a science (to encourage which all should have united in their efforts), inventors make the unjustifiable claim of monopolizing an idea, and, instead of bringing their help to their collaborators, prevent them, for no reason, from profiting by some ideas which they should have been happy to see generalized.

It is apparent that M. Bleriot is laboring under the same erroneous impression regarding the threatened monopoly as are other aviators, many of whom have reason to be well informed. That this monopoly will not come, even after the Wright patent has been declared valid, may be seen from the statement of their counsel, H. A. Toulmin, made in answer to the endless criticism aroused by the granting of the preliminary injunctions early in 1910.

The Wright Brothers have repeatedly announced their willingness to license not only individuals who wish to fly with the Wright type of machine, but also to license exhibition managers, committees promoting exhibition meets and, in fact, anyone who wishes to use for any purpose a Wright machine or an infringing machine. Indeed these gentlemen have, to my knowledge, extended a helping hand again and again to other experimenters. They have supplied them with valuable data worked out by themselves, that other inventors might produce different and better machines if they could. This very fact was alluded to in the learned opinion of Judge Hazel in suit against the Herring-Curtiss Company. The Wrights have gone so far as to announce, and the fact has been published, that even though an experimenter were using a Wright machine or an infringing machine, he would not be molested so long as he confined his work to experimentation and did not seek to get money returns.

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*This statement is directly contrary to Berget's claim—"Conquest of the Air,"—that the French machines may be controlled by amateurs after a few flights; whereas the Wright machine requires a long apprenticeship.—Ed.

†See descriptions of special types of American machines on same plan.—Ed.

The chief development of importance during 1911, where the legal situation was concerned, was the granting of an injunction in favor of the Wright Brothers against Claude Grahame White, by Judge Hand, sitting in the United States Circuit Court for the Southern District of New York. So far as White personally is concerned, this settles the validity of the Wright patent, though where the patent itself is concerned, this does not alter its status. As the result of the injunction White can not fly in the United States without permission of the Wright Brothers, and if they do grant the necessary permission, he must either fly a Wright machine, or pay royalty on the one he uses, while the decision also opens the way for an accounting for the damages accruing from White's use of infringing machines from November, 1910, or even earlier, another action having been started for that purpose. The action, favorably ended for the Wrights by Judge Hand's opinion, was a suit for infringement and accounting by reason of the defendant's use of Farman and Bleriot machines in this country, claims 3, 7, 9, 14, and 15 of the Wright patent being involved. No proofs were presented by the defendant and the validity of the Wright patent was not seriously disputed. Judge Hand, among other things, states:

> In the form in which the case arises there can not be any substantial doubt of the right of the complainant to an injunction. The defendant has put in no proofs upon any of the issues raised in the answer and the patent is sustained by its own *prima facie* validity. I shall adopt the same interpretation which I put upon it in The Wright Company vs. Paulhan, and hold that the fixed connection between the rudder and the warping mechanism is not an essential feature of the claims, but that the only connection between the two may be made by the intermediation of a human body and a human will. The defendant, while not conceding the validity of the patent, does not seriously challenge it, or argue that his biplanes have not infringed it. I have, therefore, no alternative but to grant an injunction.

It may be another year or two before the Wright-Curtiss action, which is the only suit pending that has the validity of the patent as its issue, will be decided in the lower court, as further time has been granted in which to take testimony before it goes to trial in the United States District Court at Buffalo. As there will undoubtedly be an appeal, regardless of which of the litigants is favored with a decision, it may be several years before the patent rights of the plaintiffs are actually established.

During 1912, action is to be taken generally against makers and aviators in this country who are manufacturing and exhibiting alleged infringing machines. This is not the legal procedure originally planned by the Wright Company, but one that has been forced upon it, more or less, by public censure. The original intention was to bring infringement suits against makers or users of the principal types of machines, such as Curtiss, Farman, and Bleriot only, and to obtain as early an adjudication as possible for the benefit of the art and industry, for not until final confirmation or dismissal of the Wright claims would capital be likely to invest in aviation nor would the public buy machines of the types involved. The progress of the actions against Paulhan, against Curtiss, and against White has already been outlined. It is questionable, in case injunctions are granted, as would appear likely in view of the White decision, that damages could be collected from defendants permanently resident in France, though it seems probable that the English courts would favorably view the judgment of an American court and compel payment of the claims against White.

Criticism was quite general of the action of the Wrights in selecting the few defendants mentioned, and there was considerable wonderment as to why the Moissant aviators were not prosecuted, why Sopwith was allowed to import and fly machines in this country, and why Ovington, Baldwin, Willard, and the large number of lesser lights who are killing the prospects for future meets and exhibitions all over the country by failing to satisfy the public curiosity, or even to fly at all in some instances, were left to do as they pleased. Actions have accordingly been begun against many of the aviators in question and still others will be sued. The policy of the Wrights in this connection is made clear by the appended statement of F. H. Russell, general manager of the Wright Company.

> Our first desire was not to bother the general public until it could be informed as to the legal status of the Wright patent, but with such rapid

developments in this country, and with the coming over of foreigners who are not interested in development, excepting in so far as they would make money to take away from the country, we were becoming criticized for the very policy which we considered most broad and liberal. Then, too, by refraining from these further suits, we might be considered as acquiescing, to the detriment of our legal position.

Another reason, quite as important as the popular feeling (above expressed), which has altered our policy, is the fact that manufacturers and licensees in these exhibitions who have recognized our patents and paid our royalties, are very rightly requesting the protection in their business which they feel the patents should insure, and which they have paid for.

Legislation. The practical use of the aeroplane and the airship has brought with it new legal problems, which are now the subject of attention in several countries. In view of its leading position in this field, France has already taken the first step by adopting a code of laws to regulate aerial navigation in that country, the object being to protect the public against inconveniences and risks which may result from imprudent and daring aviators, quite as much as to regulate the users of the machines themselves. The code adopted comprises six chapters with forty-two provisions. It requires all "airships" (dirigible balloons or aeroplanes) to bear a visible registration number, and to carry a log book in which the names of all persons carried and the times and places of departure and arrival are entered. No explosives are to be transported except by special permit, while wireless and photographic apparatus is also prohibited without permission from the minister of public works. Flights over cities and crowds are prohibited and the airship must alight whenever officially signaled to do so, though just what the signals are to be has not been settled. Dirigibles must carry "sailing lights" between sundown and sunrise, exactly the same as in marine service, *i. e.*, a white headlight and red and green lights to port and starboard, respectively. Aeroplanes have been given temporary permission to carry a single light, but it must show white ahead and red and green to left and right, similar to the small combination motorboat lights used in this country.

However, American law is based upon the English common law and, as the latter differs radically from the French code, the situation in both countries where aeronautics is concerned is totally different. In view of the old legal maxim that ownership of the land extends to the center of the earth and to the sky, or in other words, indefinitely in both directions from the surface, there would appear to be no public right to the atmosphere at all. But no square decision has ever been made on this point, while the numerous dicta of which it has been made the subject would indicate that the maxim is rather lightly regarded, it having been referred to in one instance as a "fanciful phrase." But it is only when the possession of the soil is interfered with that the airman is likely to infringe upon the rights of property owners. That point of view is taken in most of the European codes. For example, in the German code it is stated that a property holder can not prohibit such interferences undertaken at such a height or depth that he has no interest in the prevention.

Probably the first laws to be enacted in this country will concern human safety and not property. In view of the accidents that occurred at Paris on the occasion of the start of the Paris-Madrid race in the summer of 1911, it seems unlikely that air craft in Europe will be permitted to fly over large cities or towns owing to the possibility of being compelled to descend because of a crippled motor or lack of fuel. On the other hand, the open country and navigable streams will doubtless be unrestricted.

Forced descents may perhaps render it necessary to treat the airman more leniently than is possible under the common law. In a New York case (Guille vs. Swan, 19 Johns. 381), decided in 1822, an aeronaut was held responsible not only for the direct damage caused by the descent of his balloon into a garden, but even for the consequential damage caused by the crowding of strangers upon the property to satisfy their curiosity. Governor (formerly judge) Simeon Baldwin of Connecticut reviewed the problem in an article in the *American Journal of International Law* (1910) in which he raised the question as to whether the law of self-preservation might not be invoked by the airman who is compelled to make an immediate landing to save his own life and in so doing accidentally causes the death of another. Under ordinary circumstances, he considered it advisable to indicate by some simple means where landing was prohibited and where permitted. As a matter of general policy it would not seem that the aviator should be made to pay more than for the direct damage for which he himself has been responsible.

To avoid these forced descents, and to insure as careful control of air craft as possible, licenses to navigate the air will undoubtedly be necessary. Most of the bills pending before State Legislatures in this country and which will probably be enacted generally during the next year or two provide for such licenses as one of their most important features. In this country, it is questionable whether the States should be permitted to issue such licenses in preference to the Federal Government, though attempts to have a law of this nature passed to control automobiles have extended over a number of years without success. With aeroplanes traveling anywhere from 40 to 90 miles an hour, several of the smaller States could be traversed in the course of a day. The conditions are so radically different and the distances covered so great that the present practice of one State recognizing the automobile licenses of others would mean the practical nullification of any State's license act. The right of the Federal Government to license air craft would appear analogous to that of regulating navigation on coastal as well as inland waters.

Questions of aerial international politics have already given congresses which have met in Europe no little concern but, on the whole, there appears to be a tendency to apply the principles of maritime law to air craft. The American Political Science Association has suggested that the right of the air craft of one nation freely to traverse the air space of another might be compared with that of the vessel of one State freely to navigate the waters of a co-riparian State. The abortive convention drafted by the International Conference on aerial navigation in 1910 was based entirely upon the provisions of international maritime law. There are the same requirements as to registration and nationality of the vessels, the same method of determining the fitness of the craft and the competence of its navigators, and the same regulations applying to the sojourn of air craft in distress. Provision is also made for the keeping of logs, customs supervision of the atmosphere, the right of police, the regulation of passenger and freight traffic, the prohibition of navigation in certain zones in the vicinity of fortifications; and there is even a tendency to incorporate a principle analogous to the three-mile neutral zone of maritime law, but there appears to be no agreement as to the height of the zone as yet.

Customs. Aeroplanes have also caused more or less trouble to the customs authorities of various countries, entirely aside from their adaptability to the dark ways of smugglers. For instance, Mexico classes the flying machine, when imported complete, under the head of "articles not specially mentioned of iron, steel, or tin plate, etc.," while Canada places the aeroplane in the same category as "telephone and telegraph instruments, batteries, motors, dynamos, and electrical apparatus not otherwise provided for." In India the Governor General is given authority to make regulations concerning the admission of aeroplanes, or to prohibit their importation entirely. The duty in this country on a complete machine is naturally affected by the fact that it is equipped with a motor, bringing it under the head of "manufactures of metal," which makes the rate on the entire machine 45 per cent *ad valorem*, substantially adding to the cost of a foreign machine in this country.

MILITARY IMPORTANCE OF AEROPLANE AND DIRIGIBLE

Whenever a new development receives a great impetus, as has been the case with aeronautics generally within the past few years, prophecies abound. The day when the aeroplane will be utilized in a similar manner to the automobile appears to be so far distant, at present, that the imagination naturally reverts to something more immediate—and that something has taken the form of the military importance of the aeroplane and the dirigible. Owing to the great expenditure involved in the construction and maintenance of the latter, its chief destiny appears to lie in this direction. When the submarine torpedo was perfected, prophecies to the effect that here, at last, was an instrument that would make war impossible in future, were freely made; the submarine boat and the Dreadnaught type of battleship met with similar acclaim. Despite the lack of fulfillment that has attended these prophecies, they have been dragged out again and made to serve in the same rôle for the aeroplane. As was naturally to be expected, much that is erroneous and misleading has appeared regarding the latter as well as its bulkier and more costly comrade-in-arms, the dirigible. That the "aerial navy," however, is already an established fact will be evident from the following, which represents the strength of this "new" arm of the various military establishments of the world.

Attitude of Military Powers. France maintains 4 dirigibles of an aggregate of 395 horse-power, and 38 aeroplanes, mostly of the monoplane type; Germany has 7 dirigibles of 1,160 horse-power, and 24 aeroplanes, mostly Wright biplanes of German manufacture; England has 3 dirigibles of 365 horse-power, and 3 aeroplanes, all biplanes; Russia has one 70-horse-power dirigible and 6 monoplanes; Italy has one 100-horse-power dirigible and 8 Bleriot monoplanes; Spain has one 100-horse-power dirigible and no aeroplanes; Austria has one 70-horse-power dirigible and 4 biplanes; and the United States maintains one Baldwin dirigible of 30 horse-power, and one Wright biplane. This brief statement gives some idea of the relative strength of the various nations at the end of 1910, and in the case of France plans had already been made to increase the equipment by more than 50 per cent, while in Germany activity in the same direction is also very much to the fore.* Japan and even Turkey are experimenting with both types of machines with a view to making them a part of their military service. The backwardness of the United States in this respect is explained by the great advantages of its natural position, but it is anticipated that more interest will soon be taken in an aeronautical division of the army, while experiments to make the aeroplane an auxiliary of the navy have already been undertaken.

Considerable interest has been aroused, however, by the successful flights of an aeroplane from the deck of a cruiser to the shore, and by the unusual feat of alighting on a specially-built platform on a man-of-war and again leaving it. The flights of Curtiss in a machine designed to alight on or run over the surface of the water have added to the interest, so that Congress has been induced to appropriate the sum of $125,000 for further experiments along this and similar lines, it being apparent that the aeroplane will be of great importance as an auxiliary to the navy, Fig. 44. Owing to the ease with which a machine can be taken apart and put together again, it can be stowed in a very limited space and can be quickly assembled for action. As the deck of a vessel, however, would not afford sufficient unencumbered space for either starting or alighting, it is quite evident that the aeroplane evolved for this purpose will be one capable of starting from the water and alighting on it—or rather one that is able to run and alight on either water or land.

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*These figures have since been greatly increased. France has placed large orders for aeroplanes and dirigibles. England and Germany are also increasing their aerial "navies," while the United States has acquired additional Wright and Curtiss biplanes, also Curtiss hydroaeroplanes, but it is difficult to give definite figures.—Ed.

England, also, is awakening to the importance of the new arm, but appears to lean somewhat to the German view which at first regarded the dirigible of paramount importance, though Germany has since greatly increased her aeroplane fleet. During 1910, there was constructed at the ship-building plant of Vickers' Sons & Maxim, Barrow in Furness, England, a huge dirigible for military purposes. The greatest secrecy was maintained regarding the details, but it was planned to be the largest dirigible ever attempted, exceeding in size any of the Zeppelin monsters thus far constructed. It was known

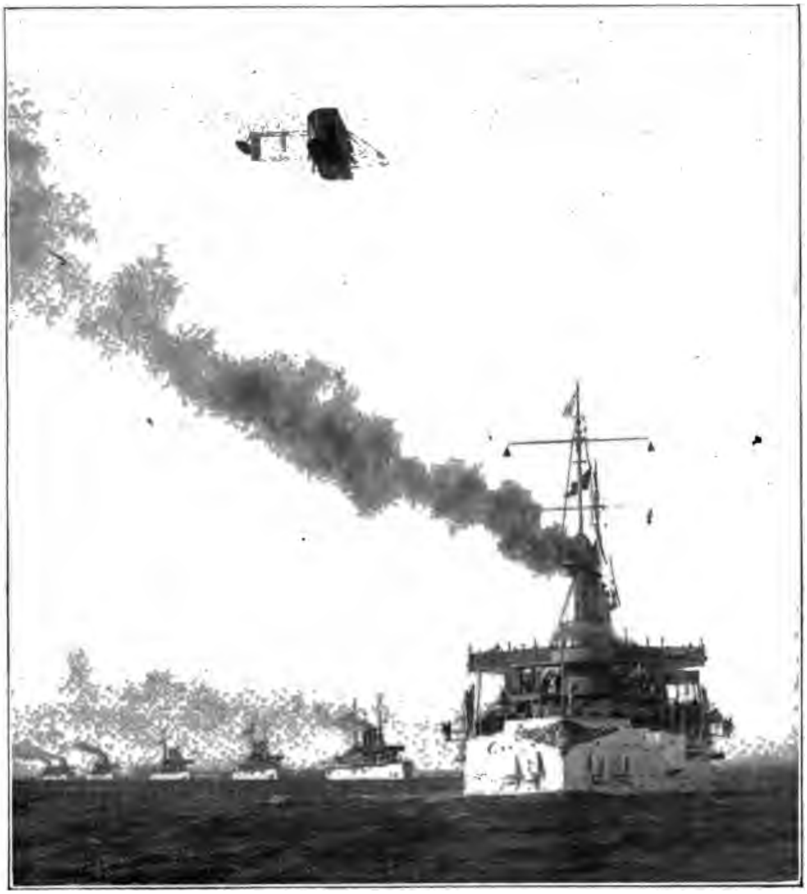

Fig. 44. The New Naval Scout: the Fourth Military "Arm"

as Naval Airship No. 1 and was equipped with motors of 400 horsepower. The envelope was covered with a metallic coating to serve as a protection and to make the gas bag rigid. It had a carrying capacity sufficient to take a complement of 34 men, but at first only six officers and men were required, a special crew being in training to man it under expert supervision. The armament consisted of a special type of aerial weapon. A second-class cruiser was assigned to special duty as a convoy for the huge airship, but the latter was wrecked the first time an attempt was made to take it out of its shed. The length of this huge dirigible was 510 feet, the diameter at the greatest girth was 48 feet, and the gas capacity was 706,336 cubic feet. The envelope was made of silk and was divided into seven sections.

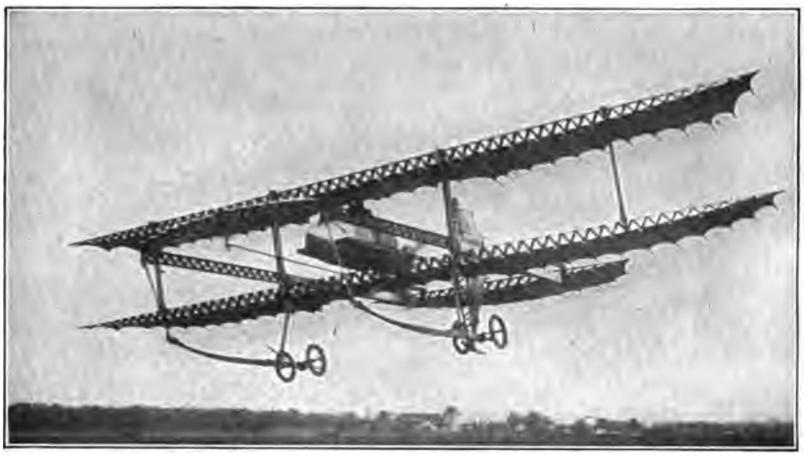

Fig. 45. Paulhan's All-Steel Aeroplane for Military Use

Power was derived from two sets of eight-cylinder, V-type, water-cooled, four-cycle Wolseley engines, designed to run at 500 r.p.m., driving three propellers which were expected to give the airship a speed of 45 miles an hour—a rate of travel not hitherto approached. To each of these engines was connected eight sheet-metal tanks, each tank having a capacity for 2,000 gallons of gasoline, making a total fuel capacity of 32,000 gallons. These tanks were welded together in airtight sections, insuring the ability of the airship to keep its motors running should an accident or injury occur to any particular section. The precaution, however, entailed the addition of 300 yards of aluminum piping for the connections. The framework was constructed of duralumin, a new alloy of aluminum which is said to be much lighter and stronger than that at present in general use.

The British War Department has also lately purchased one of the new type of aeroplane, Fig. 45, designed by Paulhan and described in detail later.

Adaptability to War. In most of the prophecies on the subject the use of air craft in war is regarded as being something quite novel and of entirely recent development. This, of course, is true of the aeroplane, but ever since Napoleon formed the first military balloon corps in 1793, practically all the first-class powers have utilized aeronautics in war to the extent to which development permitted at the time. Napoleon used balloons in Egypt, though with small success; the Austrians employed them before Venice in 1849, the Russians at Sebastopol in 1854-55, the French in the Italian campaign of 1859, the United States army in the Civil War, the French during the Siege of Paris, 1870-71, the British in the Indian and African campaigns, and both sides in the Russo-Japanese War.

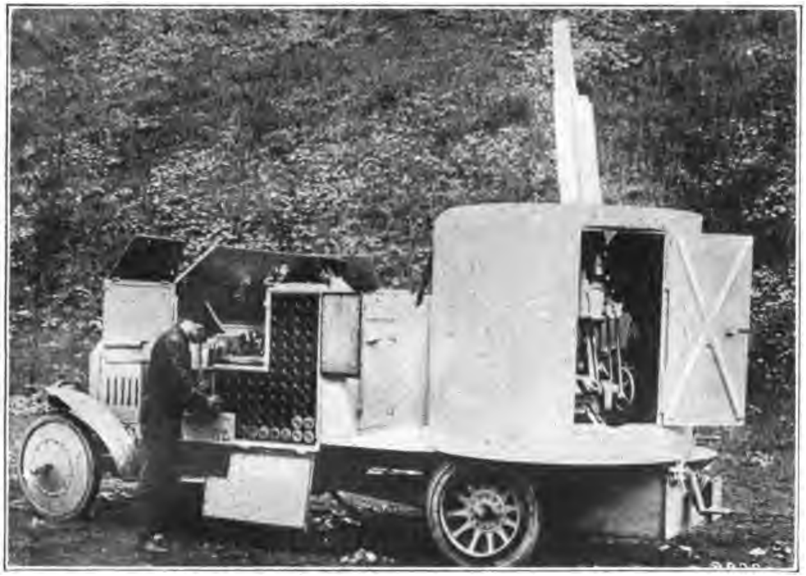

Fig. 46. Krupp Guns for Protection Against Air Crafts, Showing Open Ammunition Magazines

At first, the captive balloon was used altogether for scouting purposes, but since the advent of the dirigible the simple balloon has become obsolete for anything but purely sporting purposes. Up to two years ago, the relative importance of this arm of the service depended entirely upon the number of dirigible balloons maintained, and artillery designers have been very active in adapting their guns to firing at angles never before thought necessary. This has been the case particularly in Germany where the Krupp works have been conducting a series of experiments in firing at balloons with specially-designed guns, some of which are shown in Figs. 46 and 47. In addition to scouting, or rather discovering the enemy's position without endangering men in the latter service, the balloon has most frequently been employed for directing artillery fire, it having proved particularly valuable for this purpose both in our own Civil War, and in the Boer War in South Africa where a captive balloon was equipped with a searchlight and used at night. The history of its employment, however, may be found in detail in works on the subject and would be out of place here, except as a precedent for the development that is now taking place.

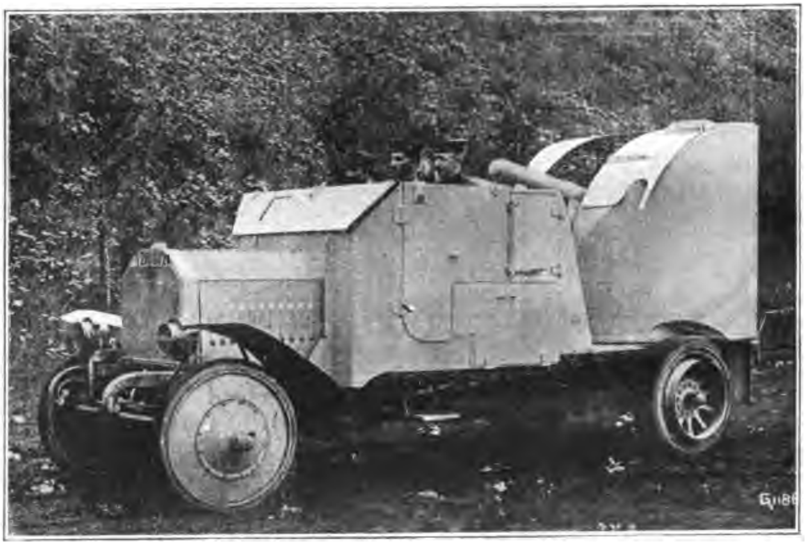

Fig. 47. Krupp Guns for Protection Against Air Crafts

The rapid development of the aeroplane and its facility of action more than justifies its ever-increasing application to military operations by the first-class powers. Such feats as Roll's return trip across the English Channel, Chavez's flight over the Alps, Tabuteau's six-hour flight, Breguet's flight with twelve passengers, McCurdy's sending wireless telegrams from a Curtiss biplane while in flight, Moisant's trip through country totally new to him by compass guidance, McCurdy's trip from Key West to Havana, and Ely's flight from a cruiser to shore and back are all accomplishments that could be put to considerable advantage in a state of actual warfare. Behind all the imaginative prophecies of airships eliminating navies, decimating armies, and utterly destroying forts and cities by dropping explosives, there is a foundation of fact which will be utilized as developments warrant it. All of the extravagant stories of the absolute invincibility of the aeroplane have not been the product of untrammeled creators with ample imagination, though the persistence with which they have been repeated has led to replies in kind which have shown a scarcely higher appreciation of the true value of the aeroplane. Even such a high authority as the late Rear Admiral Robley D. Evans is reported to have expressed an opinion that strikingly reveals how little is really known concerning the possibilities of the aeroplane.

It is only natural that those experienced in the service should express contempt for anything lauded as being so infinitely superior to the methods of warfare in which they are skilled. Nor is it anything new—the advent of the torpedo and the submarine boat brought forth a similar greeting. Some of the stories regarding the possibility of annihilating battleships and armies through dropping explosives on them were hardly worthy of anything better. It is a matter of common knowledge that to do any great damage, an explosive must be confined. An aerial bombardment could scarcely be expected to do as much damage as a naval action of the same class, and it would be far more difficult to carry on. There could be no penetration to the missiles and their damage would be confined to blowing holes in the surfaces of streets and the roofs of houses, or in the case of a man-of-war, in damaging its superstructure. Talk of this nature in connection with the destruction of battleships led Rear Admiral Evans to attempt to show how easily an aeroplane could be destroyed from the deck of a ship, Fig. 48. According to his theory, firing could begin at long range—say, 10,000 yards, or between five and six miles. As the machine approached, more guns could be utilized, and the aviator who would have the daring to approach a battleship under such a hail would be daring indeed.

But anyone who has seen an aeroplane at a distance of five to six miles can fully realize that nothing short of a miracle could ever cause it to be struck. It is the merest speck in the sky, even at a mile or so, and can best be compared to the size of a common housefly a hundred yards away. It is almost impossible to follow it with the eye, and once lost it is extremely difficult to pick up again. Add to this the fact that it is traveling anywhere from 50 to 60 miles an hour or better—speeds at which a moving object has never been shot at before, and the chances of striking it would seem to be about zero minus. Yet Rear Admiral Evans is reported as stating that it would prove an easy mark for a 12-inch gun. The futility of making

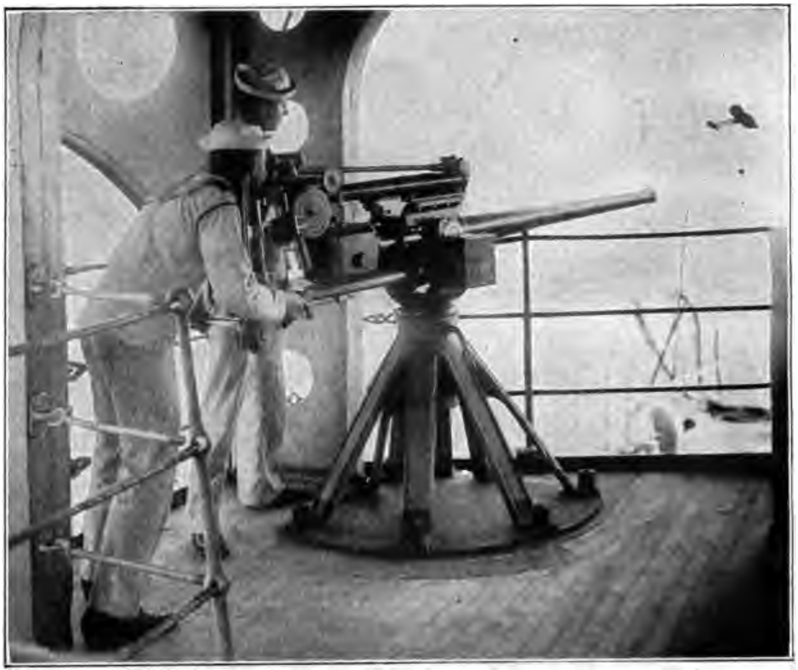

Fig. 48. Illustrating Possible Use of Small Machine Guns Against Aeroplanes

such an attempt would be on a par with trying to shoot a fly with a sporting rifle at a hundred feet while the insect was flying faster than the marksman could follow its movements through the sights.

Operations in France. *Military Maneuvers.* On the other hand while few, who are in a position to know, entertain the idea that aeroplanes will ever supersede battleships, or put an end to war, they do know that they are destined to play an important part in the war game of the future, and most nations are now seriously developing this new auxiliary as an adjunct to their military establishments. What can be accomplished with the aid of this branch of the service designed to operate in the third dimension, is probably best illustrated by brief reports of the French maneuvers held in the fall of 1910 and that of 1911 and extending over a week in each year. Owing to the extraordinary progress of military aeronautics they were carried out on an unprecedented scale. Each opposing general had at his command well-organized detachments of dirigibles and aeroplanes with the necessary stations, repair shops, and a large and well-trained personnel. In 1910, fifteen air craft took part, four aeroplanes being assigned to each corps and three being assigned to the staff headquarters, together with four dirigibles, while the 1911 maneuvers were upon the most elaborate and impressive scale ever witnessed, the number of machines employed being greatly increased over the previous year.

Three aeroplane stations were established at different points some distance apart, while immense sheds were erected for the dirigibles Colonel Renard, Liberté, and Zodiac at the Camp Militaire, while another enormous "hangar" or loft was erected for the Clement-Bayard II at Issy-les-Moulineaux, the famous French aviation field. This shed was almost 400 feet long by 100 feet high by 70 feet wide and though merely a temporary structure cost 200,000 francs, or about $40,000. A building was also put up to manufacture hydrogen gas by a new secret process employing powdered ferro-silicon treated with caustic potash. The gas thus produced is said to be much purer than is possible with the usual commercial methods and proved very satisfactory in service.

The maneuvers began with a trip by the Clement-Bayard II of a little over two hours and at an average elevation of about 1,000 feet; during the entire time it was in wireless communication with the Eiffel Tower and the military headquarters. On the following day numerous flights were made for purposes of reconnoissance, the aviators making flights of some distance and reporting back in a very short time with the information gained, despite the heavy wind that prevailed. The results of observations made by the aerial scouts were such as to force the commanders to change their plans of battle twice. Notwithstanding a wind of 26 miles an hour that was frequently accompanied by rain, numerous flights were made the next day, Latham circling the entire series of the enemy's positions in a heavy rainstorm and promptly returning to report the information he had gained.

After this, the Clement-Bayard II made a reconnoissance of an hour's duration, landed, and immediately afterward started for Paris to place the two armies in communication. The flight was made at an average height of 1,200 feet and the distance of 75 miles was made with seven passengers in two hours and seventeen minutes. Constant communication was maintained by wireless with Paris (Eiffel Tower) and during the trip a number of carrier pigeons belonging to the various divisions were released. The smaller dirigibles, La Liberté and Colonel Renard, also made a number of trips. During the latter half of the week, the second part of *les grandes manœuvres* were carried out in the course of which numerous flights were made to carry dispatches distances as great as 50 miles for purposes of observation and the like. In each case, the aviator carried a military observer with him, usually an officer of engineers, and the information obtained subsequently proved to be startlingly accurate. Although four of the machines were disabled in service, their value as scouts and dispatch bearers could scarcely be underestimated.

On the next to the last day of the maneuvers, the weather improved and there was afforded the unprecedented sight of no less than four dirigibles and eight aeroplanes in the sky at once—an unequaled opportunity to test marksmanship with the new automobile-mounted, rapid-fire gun, had the use of the latter been possible. The Clement-Bayard II started in fine weather for the last trip of the maneuvers on the final day, but was almost destroyed by a storm before landing. The airship was caught by a violent wind and sent along at a speed greater than that of an express train passing below, while the lightning played so fiercely against the steel sides of the car and the wireless apparatus that it was feared that the hydrogen would be ignited.

The successful carrying out of military maneuvers on such an extended scale with the aid of airships and aeroplanes may be regarded as marking the advent of a new era in armaments. The French army has officially adopted the aeroplane as a "fourth arm" and as the result of the trials in question has decided to greatly increase its equipment. No less than twenty Farman biplanes and ten Bleriot racing monoplanes were ordered, which would bring the total to sixty machines in service. The new aeroplanes are designed to have a radius of action of 150 miles, lifting capacity sufficient to carry three men and 50 pounds of weight besides, and are to be equipped with a second or reserve motor. They are of the portable type as shown by Figs. 49 and 50. In addition, three military flying schools have been established and are to be augmented by four more. To

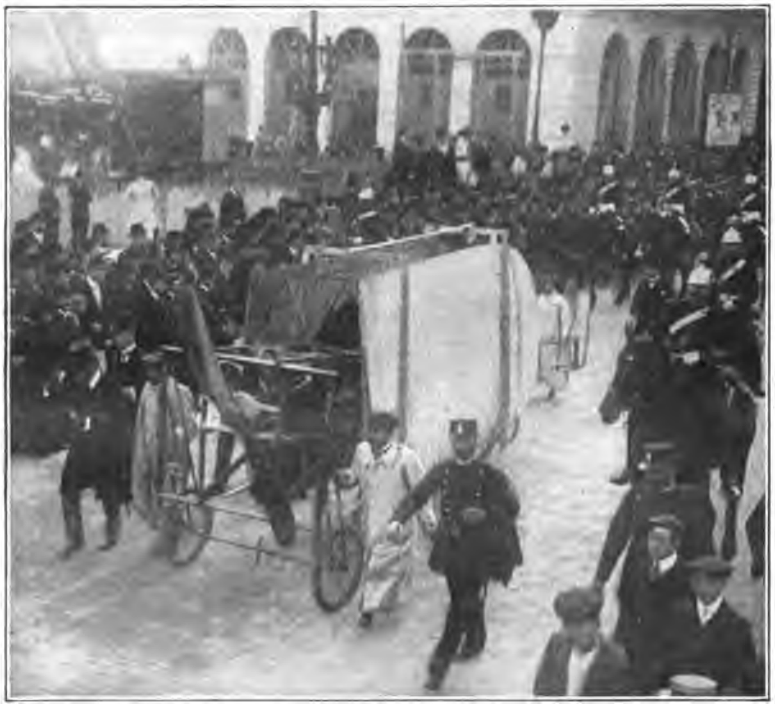

Fig. 49. Portable Type of Monoplane for Military Use

each of the new stations will be assigned twelve machines and twenty aviators. Stations are also to be established along the coast, those mentioned all being inland.

Military Aeroplane Tests. For the selection of more aeroplanes for this purpose, an open competition was held in the latter part of 1911. The general conditions to be fulfilled by the competing machines were as follows: To be built entirely in France of French materials; to be able to fly 186 miles in a closed circuit without a stop, and with a useful load of 660 pounds in addition to the fuel, oil, and water necessary for the trip; to carry three persons comfortably—the pilot, mechanic, and an observer; to have a mean speed of 36 miles per hour; to be capable of alighting without accident on stubble fields, plowed ground, sowed or clover land; and to be able to arise easily therefrom; also to be capable of easy transportation, whether dismantled or not, by road or rail, and to be easily and rapidly put together without minute adjustments.

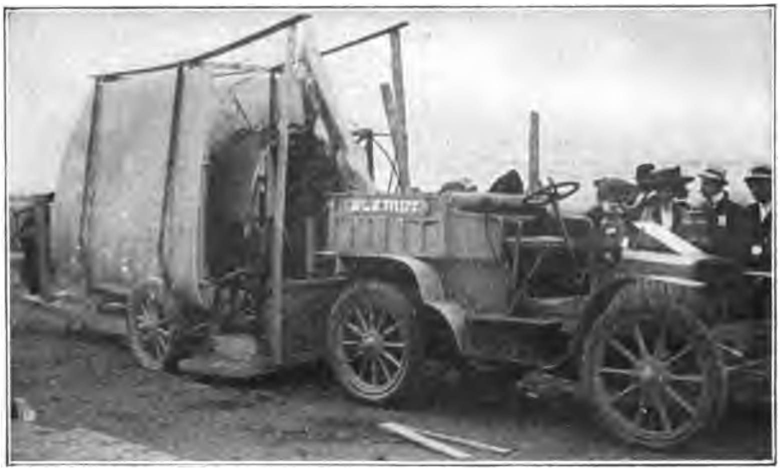

Fig. 50. Portable Bleriot Mounted for Quick Transportation

After having satisfied a committee that it was entitled to enter the competition, each machine was put to a series of severe elimination tests, those passing the latter being entitled to enter the final test for classification. In the elimination tests, the machine was weighed and all parts stamped. Any part could be replaced during the tests by an exact duplicate, but no modifications were allowed, except in the case of propellers and wheels. It was necessary, however, to repeat the entire test from the beginning in case a part was replaced. Each maker was compelled to declare the amount of gas and oil required for the flight of 186 miles, and only this amount was provided. The first test was a cross-country flight carrying 660 pounds useful load, landing in a clover field between two flags 225 feet apart. Each machine was then required to arise from the same spot, circle, and re-alight on the same ground. It was then dismantled and returned to the starting point by road. The same test was then repeated, first by alighting upon and rising from stubble ground, and then from a plowed field, the machine being dismantled after each test and returned to the starting point by road as in the first test. This was followed by a speed trial, making a round trip of 36 miles, which was also a test of fuel and oil consumption. In case there was a shortage of less than 10 per cent, the test had to be repeated; where the shortage exceeded this, the machine was eliminated from the competition. In the altitude test, each aeroplane had to rise 1,875 feet in 15 minutes or less, carrying a load of 660 pounds. This test had to be successfully performed twice and concluded the preliminary trials. Out of an entry of thirty machines, only nine qualified—as follows: 1 Nieuport monoplane, 2 Deperdussin monoplanes, 2 Breguet biplanes, 1 H. Farman biplane, 1 Savary biplane, and 2 M. Farman biplanes.

The final trial, termed the "classification test," comprised a round-trip flight of 186 miles without alighting, and carrying a useful load of 660 pounds, the contestants being allowed three trials each. The machines were started five minutes apart in an order determined by drawing lots. The race was one of the most interesting in the history of aviation and was successfully completed by all but one of the nine machines. As a result, the remaining eight were classified as follows:

(1) Nieuport monoplane, 100-horse-power Gnome motor, average speed 70.2 m.p.h.

(2) Breguet biplane, 140-horse-power Gnome motor, average speed 57 m.p.h.

(3) Deperdussin monoplane, 100-horse-power Gnome motor, average speed 52.5 m.p.h.

(4) Breguet biplane, 100-horse-power Gnome motor, average speed 52 m.p.h.

(5) H. Farman biplane 100-horse-power Gnome motor, average speed 50.6 m.p.h.

(6) M. Farman biplane, 70-horse-power Renault motor, average speed 45.6 m.p.h.

(7) M. Farman biplane, 70-horse-power Renault motor, average speed 43.3 m.p.h.

(8) Savary biplane, 70-horse-power Labor motor, average speed 40.2 m.p.h.

In accordance with the original program, the makers of the first machine were awarded a bonus of $20,000, an order for 10 machines at $8,000 each, and a bonus of $100 for each kilometer in excess of 60 made by the winning machine, this bonus amounting to $56,900, so that the Nieuport won $156,900; the Breguet $83,000, and the Deperdussin $59,500.

It will be noted that, throughout the maneuvers in question, no mention is made of bomb-dropping about which there has been so much talk, but which is not regarded so highly in military circles. Work of this kind is to be totally ignored in the curriculum of the schools in question. How small would be the damage done by aeroplane high explosive attack was shown by the Japanese bombardment of the Russian fleet in Port Arthur. The fire of the 11-inch siege guns, throwing a quarter-ton explosive shell, was directed by a skilled observer on a hill commanding the harbor, and the projectiles with their highly-explosive contents rained down upon the decks of the ships with the greatest accuracy, falling almost vertically. The entire Russian fleet was sunk, not by the shell fire, but actually by the Russians themselves, as subsequent examination revealed, which also showed that the damage done by the projectiles was astonishingly small. If, then, the falling of a 500-pound explosive shell from a height of two miles directly upon the deck of a ship, caused so little injury, the possibility of destroying a war vessel by means of small hand-launched bombs is practically nil. But for scouting, taking photographs, especially with the telephoto camera, and for sending information by wireless, the aeroplane is an arm whose importance can not be denied. Had such an aid been available in 1898, Admiral Sampson would have known within an hour that Cervera's fleet was resting quietly in Santiago harbor, instead of uselessly blockading the entrance to the harbor for a month, and the unfortunate Schley-Sampson controversy would never have occurred.

Aeroplane Maneuvers in United States. *Ely's Flight from the Birmingham.* That the aeroplane may be of as much assistance to the naval branch of the service as the army is already appreciated, as witnessed by Ely's attempted flight in a Curtiss biplane from the deck of the scout cruiser Birmingham to the Norfolk Navy Yard, some 30 miles from the place where he left the ship. This was undertaken in the latter part of November and, as the result of its successful outcome, attempts were made to rise from the deck of a war vessel and return to it. A wood platform 25 feet wide and 85 feet in length was built on the forecastle of the Birmingham to provide a run for the machine. This platform was given a downward slope and projected slightly beyond the bow of the cruiser, as will be noted in the illustrations of a later flight in San Francisco harbor. Ely's machine was assembled and tested at the Jamestown, Virginia, race track and then transferred to the war vessel by one of the government derrick lighters. Despite squalls of wind and rain, it was decided to attempt a flight and, starting his engine during a calm spell, Ely ran down the sloping platform at high speed and shot over the bow directly toward the water. As the biplane left the platform it settled rapidly till it struck the water with a splash, which was thought to terminate the experiment. Instead, however, the machine rose without difficulty to a height of about 150 feet and headed for shore, which was reached without any difficulty. Ely attributed his downward plunge to a faulty movement of the control wheel. When the machine struck the water, the propeller was damaged and the spray so clouded the aviator's goggles that it was only with difficulty he could see to make his way toward the land. Owing to the accident, a descent was made at Willoughby's Point, two and one-half miles distant, instead of continuing to Norfolk as originally planned. Examination showed that the damage to the propeller was slight and the flight could have been resumed, or an attempt made to return to the vessel, had this been desired.

The significant point of this performance is the fact that the aeroplane started under its own power from a vessel at rest with but an 85-foot run and a 30-foot drop. Considering the bad weather conditions, this was an excellent performance. A speedy cruiser offers the great advantage that she could be headed into the wind, or even where there was no wind, could steam fast enough to allow an aeroplane to rise from its deck without any preliminary run, while in alighting the aeroplane could simply hover above the vessel in motion and drop gently to her deck. In place of the cumbersome platform adopted for the experiment in question, all that would be needed would be troughs for the wheels to run in and these could be stowed away when not in use. For that matter, a special starting derrick, such as that originally employed by the Wright Brothers, could be used readily.

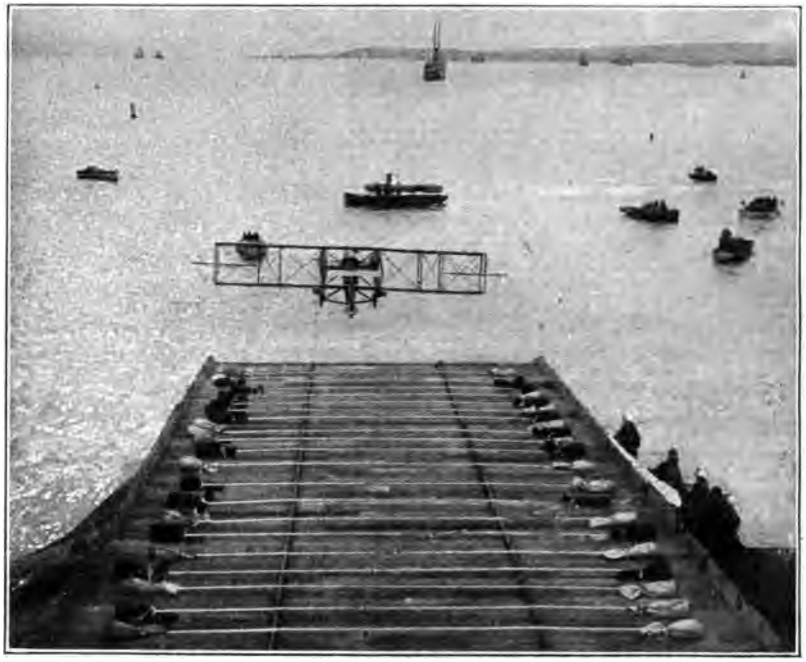

Fig. 51. Ely Making a Landing on the Deck of the U. S. S. Pennsylvania

The design of the aeroplane itself would also have to be modified to correspond to the conditions. The wheels would undoubtedly be necessary to make it possible to use the machine on land, but it should also be provided with hydroplane floats, similar to those employed on the Fabre marine aeroplane, to permit the machine to alight upon and again start from the surface of the ocean. The possibility of an aeroplane leaving and returning to a war vessel, such as the scout cruiser Birmingham, at will and with certainty should undoubtedly increase the usefulness of vessels of this type.

Ely received a prize of $500 for his flight from the United States Aeronautical Reserve, and a similar prize is offered for a flight of this kind from a merchant vessel. Two attempts to make the latter were undertaken at New York, the object being to return from a point 50 miles at sea with mail, but on each occasion a gale of wind made carrying out the experiment impossible. Curtiss himself was to have made the flight and even went so far as to have the starting platform built.

Ely in San Francisco Harbor. A few months later, January 17, 1911, Ely made a flight in a Curtiss biplane from the land and alighted easily on the deck of the U. S. S. Pennsylvania, anchored in the harbor of San Francisco, Figs. 51 and 52. This was preceded by a 12-mile flight from the aviation field where the start was made. A special platform 120 feet long by 40 feet wide had been erected on the after-deck of the vessel, canvas shields being placed at each side to prevent the machine going overboard in case it did not alight squarely on the platform. Ropes were stretched across the platform and made fast to bags of sand at either end to arrest the progress of the aeroplane, in case the skids with hooks provided especially for this purpose did not work as anticipated. Ely left the field, climbed 2,000 feet, crossed the San Bruno hills at a great height, and then

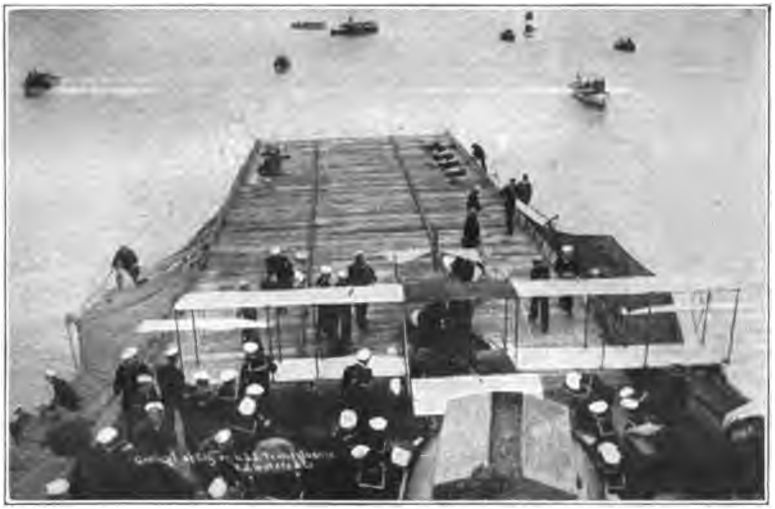

Fig. 52. Ely's Machine on the Deck of the U. S. S. Pennsylvania

descending, circled the shipping in the harbor. He headed straight for the Pennsylvania, shut off the motor while still at a considerable height, glided down to the platform and landed with perfect ease, the machine coming to a dead stop before running more than a third of the distance allowed. So little trouble was experienced in making the landing accurately that Ely was of the opinion that he could carry it out successfully in nine cases out of ten, given moderate weather conditions. Where the ship was under way and headed directly with the wind, it could undoubtedly be performed even in brisk weather. After a reception on board, Ely returned to the aviation field in sixteen minutes. As this was the second time he had started a flight from the deck of a naval vessel, he was more accustomed to the conditions and soared off with great ease.

Following these experimental flights, Curtiss perfected the hydroaeroplane and also devised a practical method of launching it from the ship on flexible wire cables, as described in the article on the "Hydroaeroplane." Curtiss also made flights to and from a cruiser in San Diego Harbor, the aeroplane and aviator being hoisted aboard after alighting on the surface alongside. The United States navy has acquired several of these machines and has inaugurated an aeronautical department, a number of the navy officers having become aviators at the Curtiss school.

Bomb-Dropping Performance. During the two days preceding Ely's flight, practical tests of the aeroplane for scouting and bomb-dropping were undertaken at the aviation field. Lieutenant Myron Crissey of the Coast Artillery dropped a special shrapnel bomb from a height of 550 feet while flying in a Wright machine piloted by Parmalee. The bomb consisted of a very thin shell of brittle white cast iron, loaded with black powder and bullets and fitted with a percussion cap. Its weight was about 8 pounds. Lieutenant Crissey succeeded in dropping it with considerable accuracy and it tore a large hole in the ground, scattering its contents round a radius of about 50 yards. This is the first time that an actual bomb was ever used in experiments of this nature and it is believed that it would be a comparatively simple matter to hit a battleship from a height as great as 3,000 feet, where the aeroplane itself would be safe from attack to a very great extent. For this purpose, however, it would appear to be more destructive to cavalry or infantry.

Scouting Operations. To ascertain the value of the aeroplane for scouting, flights were made by Lieutenant George Kelly of the 13th United States Infantry with Walter Brookins in a Wright biplane. He made sketches, drew maps, and took six photographs of the surrounding country, but failed to locate a body of troops that had left the Presidio Military Reservation a few hours before. This is the first time that an aeroplane had been utilized for military scouting purposes in this country, although employed to a considerable extent in this rôle abroad in military maneuvers, where the same inability to distinguish troops in the field has also been noted. Several errors in reporting the character of the different objects and landmarks seen were also noted, from which it is apparent that the aerial scout will require special training and experience in order to be of value to his commander, as some of the errors in question were of a nature that would have resulted disastrously had the information been acted upon in real warfare. This is not only the case when the country is viewed from the swift-flying aeroplane, but likewise applies to the dirigible, the two airships employed for scouting during the German army maneuvers, in the fall of 1910, having failed grievously.

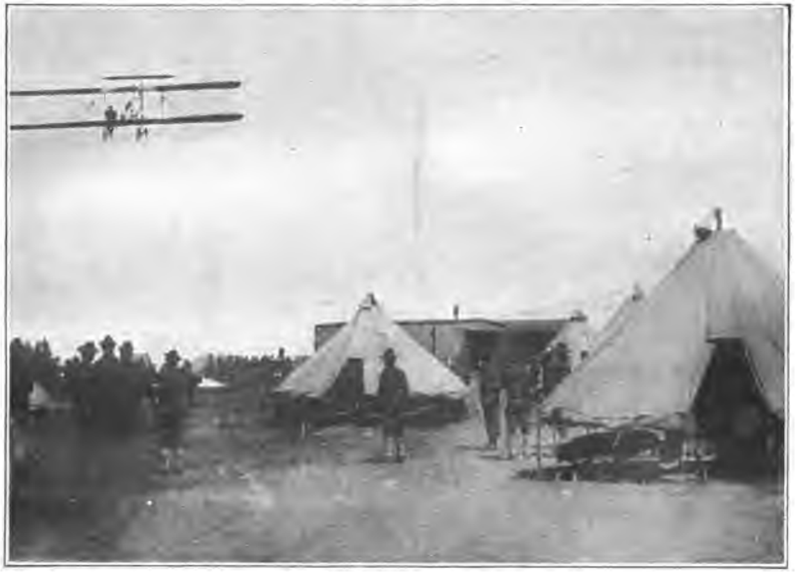

Fig. 53. Real Scouting Service by Lieutenant Foulois in a Wright Biplane

One crew led its command into an ambuscade, while the other fell into the hands of the enemy through the failure of the motor.

In connection with the French military maneuvers, a special test was arranged to learn the effect that would be produced on a troop of cavalry by the sudden appearance of an aeroplane above it. For this purpose a Hanriot monoplane was flown immediately overhead and the horses were all but stampeded by the sight of the huge bird-like object and the noise of the motor. As the first encounter of the horses with a flying man almost put them to rout, regular drills have been held since to accustom them to the sight.

Actual War Scouting. The closest approach to scouting in actual warfare thus far carried out has been in connection with the rebellion in Mexico, in February, 1911. R. F. Collier loaned the War Department his new Wright biplane and Lieutenant Foulois was commissioned to fly it above the Mexican border during the hostilities, Fig. 53. There are 1,400 miles of border to be patrolled and the government called for volunteer aviators to perform this duty. In response, Charles K. Hamilton gave his services and, on February 10, he crossed the Rio Grande from El Paso, Texas, and reconnoitered at an altitude of 1,000 feet above Juarez, locating a body of Mexican troops.

Curtiss and His Hydroaeroplane. Another test simulating actual war conditions, were the flights of Glenn H. Curtiss in his hydroplane machine from the surface of the bay alongside the U. S. S. Pennsylvania. He made a short scouting trip and, on his return, alighted on the water alongside the cruiser as easily as if he were landing on shore. These trials were made shortly after the experimental tests of this machine mentioned in connection with a description of its construction. Their principal object was to demonstrate to the War Department that an aeroplane can be made an auxiliary of the modern man-of-war without the necessity of carrying cumbrous platforms on the ship itself in order to provide a starting and landing place. Instead, the aeroplane may be stowed on the superstructure and dropped into the water by one of the cranes in the same manner as the launches are handled, though the weight is naturally but a fraction of that of the latter. Its spread of wing does not involve any inconvenience, as even with the present construction the aeroplane may be readily dismantled and packed in small compass, the operation of reassembling it requiring only about an hour, while later designs made especially with naval service in view will undoubtedly render it possible to do much better. In fact, there appears to be no reason why a folding type of machine can not be evolved, making it possible to put it in commission for a flight at very short notice. The problem of launching has since been solved by allowing the aeroplane to slide down inclined cables as described in the article on the "Hydroaeroplane."

Italian Operations. To try out its aerial equipment, the Italian military authorities put one of its airships to a severe test. This was Dirigible No. 2, which was sent from Rome to Venice, a distance of 230 miles, crossing the Apennines above the Via Maggio Pass, which necessitated rising to an altitude of 6,500 feet and occasioned the loss of a large quantity of ballast and fuel. One stop was made for propeller repairs after having traveled 90 miles, and other stops were made in the two following days, requiring four days in all to make the trip, though the actual running time did not exceed twenty-four hours. The Italian army has also made considerable use of the aeroplane in its campaign against the Turks.

GUNS FOR AERIAL WARFARE

Coincident with the development of the dirigible and the aeroplane as a fourth arm to the military establishments of most civilized countries, serious efforts have been directed toward the evolution of an arm particularly adapted to bringing down these ships of the air. The great difficulty of hitting an airship makes the usual methods of warfare totally inadequate. The fire of infantry and even that of machine guns is of little use, despite their momentary mass effect, because of the limited range and effectiveness of the projectiles and the impossibility of observing their flight. Field and siege guns can not be elevated sufficiently and howitzers are deficient in range and rapidity of fire. All these classes of artillery are lacking in proper horizontal angular range and visibility of projectiles, their deficiencies having been proven by experiment.

Special guns are therefore required and no little attention is being given their design at the moment. Various types of such guns have already been developed by Ehrhardt, Krupp, Schneider, Skoda, Vickers-Maxim, and others abroad and in this country as well. The latter have been constructed in the American government arsenals, but so far there has been comparatively little interest in the subject here. Two guns of American make—one a 2-inch 30 caliber, and the other a 3-inch, both mounted on wheeled carriages, were tried without success against captive balloons, in 1909. One of these was the McClean-Lissack automatic rapid-fire gun, which was mounted on a 3-ton Packard truck, the tests being carried out at Cleveland, Ohio, under Lieutenant-Colonel O. W. Lissack of the Ordnance Department, U. S. A. The gun fired 3-pound shells at the rate of 100 per minute, the range being 3.5 miles, but as the ordinary shells were employed, their flight could not be followed by the eye. Shots were tried with the brakes of the car set and also released, there being no shock felt in the former instance, while only a slight movement due to the recoil was noticeable in the latter.

Because of its speed, weight, and strength, the automobile is particularly adapted not only for carrying light guns of this type, but also for providing a platform from which they can be fired with a reasonable degree of accuracy. Indeed the artillery motor car, armor-plated and carrying a gun bolted directly to its chassis, is the natural counterpart of the familiar armored train, and quite a number of armored and semi-armored automobiles carrying aerial guns have been developed abroad during the last year or two, Fig. 47.

Guns employed for attacking airships or flying machines must possess a maximum elevation of at least 70 degrees, a horizontal angular range of 360 degrees, and must further be capable of rapid handling. In Ehrhardt's 5-centimeter (2-inch) automobile gun, an attempt is made to satisfy these requirements by aiming the gun, which is supported at its center of gravity, with the aid of a shoulder rest to which the sights are attached. This method gives a maximum elevation of 70 degrees. The gun is mounted in an armored turret with a lateral range of 60 degrees to right and left, the turret itself forming part of a completely armored automobile. The same gun is also mounted on a semi-armored car, giving the gun a horizontal range round a complete circle.

For this purpose, Krupp has developed guns of 2.6-, 2.8-, 3-, and 4.2-inch caliber, with the trunnions close to the breech and having a maximum elevation of 75 degrees. As employed on automobiles, ships, and fortifications, the guns are mounted on carriages which rotate on pivots, while for field use a wheel carriage with a two-part axle, the halves of which are attached by hinge joints to the front of the long carriage, is employed. The rear end of the carriage is pivoted to a rail resting on the ground. If both wheels are brought in front of and locked beneath the gun, the latter can be revolved entirely round the pivot so as to point in any direction by turning the wheels by hand. Small changes of direction are obtained by means of an upper carriage which can be turned 5 degrees to the right or left. The durability of this construction has been proved by extensive trials.

The Schneider weapon is a 1.9-inch 60 caliber gun mounted in an armored turret carried on a completely armored automobile. The gun can be elevated 70 degrees, while the turret can be revolved round a complete circle. The Skoda is a 1.5-inch 70 caliber gun (caliber in this connection refers to the length of the gun) with a maximum elevation of 80 degrees. The Vickers firm, which, according to report, has brought out a 6-inch field howitzer suitable for use against airships, has also produced a 1.9-inch 3-pounder gun designed for use on fortifications, ships, and automobiles. A maximum elevation of 90 degrees is claimed for this gun, which, like Krupp's, has its trunnions near the breech and is elevated by a rack and pinion.

The aiming mechanism of a gun employed against airships must be such as to enable the gun pointer to follow every movement of the swiftly flying adversary. With Ehrhardt's gun, this is effected by sighting as with a rifle. Krupp employs two parallel connected telescopes, with verticals and reflecting eye pieces. One man aims the gun with the aid of one telescope; another, using the second telescope, elevates the gun and fires at the most favorable moment, without oral consultation with his partner. On steeply sloping land, the elevation required for a given range can not be obtained accurately from any published tables, so the telemeter is used instead. The necessary rapidity of fire is obtained with a self-closing breech, while great range and accuracy are secured by the employment of an unusually long gun and high muzzle velocities.

In airship warfare, the question of ammunition is particularly important. Shrapnel is not well suited to the purpose. With a large number of bullets and fragments the gas bag may be cut, allowing the gas to escape; but, while serious damage may thus be done to airships of the flexible and semi-rigid types in which the gas is confined under considerable pressure in order to give stiffness, several of the separate gas bags of the rigid type might be pierced without bringing it down. Nor can complete success be reasonably expected by shrapnel connected by chains 8 to 10 inches long, as employed in the Italian experiments, or from shrapnel with rotating blades and fuses for the purpose of cutting the bag and igniting the gas. An additional difficulty in the employment of shrapnel is involved in determining the proper length of time at which to set the fuse, which does not agree with the tabular time of flight corresponding to either the measured distance of the object of attack or the distance deduced from the angle of fire. The setting of the time fuse, therefore, requires calculation, which is incompatible with rapid firing. The fuse also tends to burn very irregularly in the upper atmospheric strata of varying density which the projectile may have to traverse.

The most promising method of attack, therefore, is apparently to endeavor to strike the airship directly with shells and destroy it by their explosion and the scattering of their fragments. Ehrhardt has devised a shrapnel shell provided with a fuse for the ignition of the balloon gas. Krupp's shell has a contact exploder sensitive enough to be operated by impact on the envelope of the airship, which it penetrates before exploding in the interior. In the gun, this very sensitive exploder is prevented from going off by a mechanical device. A special slow-burning fuse reveals the course of the projectile through the air by its light at night and a heavy trail of smoke by day.

In this connection, it is appropriate to refer briefly to the method of firing. As the hostile airship is usually visible only for a short time and sometimes moves very swiftly, it can not be hit by direct aiming, even with the easily-observed fire shells. In order to utilize fully the few favorable moments, a number of shots are fired in rapid succession, varying slightly in direction and elevation but aimed in general accordance with the measured or estimated distance with proper allowance for the slope of the land, and corrections based on observations of the visible flight of the successive shots.

The diameters of the guns mentioned vary from 1.5 to 4.2 inches. But the effectiveness of such a small arm as the Skoda gun with its 1.5-inch diameter and firing a projectile weighing only 1.7-pounds is questionable, and the same remark applies to the 1.9-inch Schneider and Vickers-Maxim guns. The diameters most suitable for field work appear to be those between 2.4 and 3 inches, as they combine the requisite mobility of the gun with an effective explosive action, and also allow shrapnel to be employed. Although shrapnel appears to be ineffective against airships, as already pointed out, the possibility of employing it makes the gun useful for other field work. Krupp specifies a gun of 4.2-inch caliber for naval and fortification use.

In addition to these technical requirements, certain tactical qualities are also requisite. Guns employed for aerial warfare must possess great mobility in order that they may be rapidly transported from place to place in attacking scouts of the air. The automobile appears to meet every requirement. As it can be made strong enough for all military purposes, it allows the employment of a central pivot mounting especially well adapted for guns employed against airships; it can carry armor and can also transport the gunners and ammunition rapidly. An automobile thus armed, equipped, and protected by armor, is so heavy, however, that its speed can not greatly exceed 30 miles an hour, so that it would hardly be capable of pursuing airships traveling with a favorable wind which would bring their speed beyond its reach.

WIRELESS TELEGRAPHY IN AERONAUTICS

WIRELESS ON DIRIGIBLES

Early Experiments on Balloons. It will be apparent that one of the most valuable features of the use of the dirigible and the aeroplane in warfare is the possibility of communicating with headquarters by wireless telegraphy, which means the instant reception of information gained by scouting parties. Not long after the invention of sending messages through the air became a reality, Professor Slaby demonstrated that wireless signals emitted by a land station can be received by a balloon, floating freely in the air. The experiments were carried out in conjunction with the maneuvers of the Prussian balloon corps, and since then experiments have been made successfully in other countries. The balloon Condor, which made an ascension near Brussels in the latter part of 1909, maintained uninterrupted communication with the station on the Brussels Palais de Justice, and also caught signals sent from the Eiffel Tower at Paris, 180 miles distant. Prior to this, Professor Hergesell had already demonstrated the great value of the application of wireless telegraphy to balloons by controlling the valves of unmanned sounding balloons (small balloons sent aloft for the purpose of carrying meteorological instruments), at heights extending to ten miles, by wireless impulses. The receivers of the balloons were tuned to different wave lengths, so that the valve of any one balloon could be opened and that particular balloon brought down at will.

In a series of experiments made with the German military balloon Gross II, in the autumn of 1908, messages were successfully sent from, as well as to, the airship, the first balloon wireless stations being constructed according to the Telefunken system. It was proved by preliminary experiments in the balloon shed that the danger of igniting the contents of the gas bag by sparks emitted from the wireless apparatus could be averted by taking suitable precautions. This danger is least with airships of the flexible and semi-rigid types, in which the gas bag possesses very few metallic parts that could draw sparks from the highly charged aerial which is used for sending and receiving the flashes from the air. The suspension of the car of the Gross by hempen ropes insured the complete insulation of the electrical apparatus from the gas bag, and all parts at which sparks were formed were enclosed in gas-tight envelopes. For military reasons, the details of these experiments were not made public, but the results are said to have been very satisfactory.

These experiments have proved that electromagnetic waves are propagated to great heights in the atmosphere and that the part played by the earth in wireless telegraphy is far less important than has been assumed. Thus, one of the principal theoretical objections to the application of wireless to airships has been shown to be fallacious. In the German army maneuvers of 1909, the Gross II demonstrated, for the first time, the practical utility of wireless telegraphy on a scouting balloon. The Zeppelin airship which took part in the maneuvers did not possess this advantage. Subsequently, the Zeppelin III was equipped with wireless apparatus and it was shown that even with a rigid, metallic-framed airship of this type, wireless signals could be transmitted with safety to a distance of 300 miles or more. All of the later Zeppelin airships which have since been wrecked, particularly the passenger-carrying types, were equipped with wireless.

Dangers from Electric Discharge. While of inestimable advantage, the presence of the wireless apparatus on a metallic airship exposes it to new dangers, some of which are also present in the case of the aeroplane. The chief source of risk is the large volume of inflammable gas necessary for flotation in the case of the huge dirigibles. In a thunder storm, a balloon is subject to sudden variations of electric charge which may produce sparks capable of igniting its contents. Wireless signals are accompanied by equally great and rapid changes of potential which may produce the same result.

It seems probable that the destruction of the Zeppelin airship at Echterdingen was due to atmospheric electric discharges during a thunder storm, while the catastrophe which befell the French military dirigible La Republique in September, 1909, also appears to have been due indirectly to an electric spark. A hole was torn in the gas bag by the breaking of a propeller blade, which in itself would not have been sufficient to have caused the sudden drop of 300 feet. It is a well-known fact that gas or steam, escaping rapidly from an orifice, will acquire an electric charge which may produce powerful sparks, and it is thought that this took place immediately following the rupture of the gas bag of the Republique, setting its contents on fire.

As the gas can not be ignited by discharges from the envelope itself, the netting, ropes, and similar poor conductors (unless they become saturated with water), but can be easily set fire to by sparks from the metal parts of the valve and other masses of metal, it is obvious that all metal and other good conductors will have to be eliminated from the envelope. There seems to be no objection to the presence of metal in the car, while a well-conducting drag rope is a safeguard against explosion in landing. If all conductors are removed from the vicinity of the gas bag, there would appear to be no danger in the application of wireless telegraphy to airships of the flexible type. If the same precautions be taken, dirigibles of this class are no more liable to ignition by atmospheric electrical discharges than the free balloon.

In rigid airships with metallic frames, the conditions are totally different. It will be apparent in the Zeppelin type, with its aluminum frame and its numerous gas bags filled with hydrogen, every condition of easy ignition is present. Between the great cylindrical conducting frame, which is more than 400 feet long and 40 feet in diameter, and the surrounding air, there may exist a difference of potential of 65,000 volts when the airship is horizontal, and of 50,000 volts, when steeply inclined. A spark capable of causing ignition may be caused by a difference of potential of only 3,000 volts. As it does not appear to be practicable to substitute wood for the aluminum framing, Zehnder recommends protection of the airship by lightning rods projecting beyond the reach of escaping gas. He also suggests making the gas container of sheet metal, the stiffness of which might make it possible to employ a lighter skeleton, thus keeping the weight within the same limit as at present. No electrical discharge could take place within this metallic envelope and the induced surface charge would escape harmlessly into the atmosphere from projecting seams and points. As an additional precaution, the aluminum cars could be connected with the aluminum balloon at several points by a number of wires, so that the aeronauts would be enclosed in a sort of Faraday's cage, protecting them from external electrical influences.

Preventive Methods. The experiments of Professor Wiener have not only served to demonstrate the value of a wire cage as protection against electrical discharges, but likewise have illustrated what happened to a balloon when struck by a spark. For this purpose, a model balloon was suspended above a large induction coil with the gaps of the secondary so arranged that the largest diameter of the balloon was between one pair, while a second pair was located to discharge immediately below the valve opening of the balloon. When a spark was passed completely through a collodion balloon, filled with either hydrogen or illuminating gas, the gas ignited without explosion so that the balloon was quietly consumed. It is only when the balloon contains air mixed with gas that explosion takes place. A balloon can even be traversed by sparks without being ignited. Metzeler has recently introduced a balloon material composed largely of aluminum for the purpose of protecting the gas from the sun's rays, but experiments prove that this material is no better conductor than the ordinary balloon fabric. Sparks can be passed through a balloon of Metzeler's material without causing ignition and even collodion balloons can transmit a few sparks without burning. If the flow of sparks be so rapid and dense as to resemble a flaming arc, it may directly ignite the fabric. Even if it were possible to make a balloon of conducting material, it would still be desirable to surround it with a wire cage, as lightning naturally follows the shortest path. With this provision, the conductivity of the balloon is of no importance. Owing to its greater strength the wire netting need not be heavier than the hemp netting ordinarily employed on dirigibles of the flexible and semi-flexible types. All the experiments just referred to were made with unprotected balloons, but a model surrounded by a wire cage allowed ordinary sparks to pass indefinitely, while it also withstood a flaming arc for a short time, without igniting—fifteen seconds direct contact with the flame was necessary to produce ignition. The ropes supporting the car must also be of wire and must completely surround the car. It might be supposed that making the outside of the balloon a good conductor would rather invite danger from lightning, but this is not the case. Although the ordinary balloon envelope is a fairly good insulator against low voltages, it is unable to resist the high tension of atmospheric electricity. An electroscope charged to 2,000 volts is discharged in less than a second, when it is touched with a roll of balloon fabric about six inches long. Hence, the balloon increases the electrical tension immediately above and below it, as much as it would do if it were a perfect conductor, but when the discharge occurs, its destructive action will be greater in proportion to the electrical resistance opposed to it. It might also be objected that the Faraday's cage would prove a source of danger to the occupants. The discharge, however, passes chiefly through the wires, and only partial or inductive discharges can strike those in the balloon. It is evident that the Faraday's cage is quite as readily applicable to the aeroplane as it is to the dirigible, though its use might complicate the employment of the aerial for wireless telegraphy, as referred to later.

On the other hand, it is quite possible that the surrounding network of wire might be employed for both purposes by suitably protecting the instruments. But even when a balloon is thus protected from lightning, it is exposed to another danger, atmospheric electricity. A balloon has been ignited and consumed by small sparks produced by touching the escape valve after landing. This valve and the filling tube, normally open during flight, are the two places in which the gas can come into contact with the air and therefore need special protection. The simple and long-known device employed in the Davy safety miner's lamp can well be employed for this purpose. These safety lamps are designed to protect miners from explosions of fire damp, the flame being surrounded by a fine wire netting which conducts heat so well that the temperature required to ignite the gas can not be produced on the outside. Any gas which enters the lamp burns quietly without producing an explosion. Both the escape valve and filling tube of the balloon could be surrounded with a fine netting of copper wire, which would also afford protection from lightning in certain cases.

An electric discharge may be precipitated by pulling the valve cord in a strong electric field, as, according to Paschen's experiments, the gap that a certain tension will bridge is greater in hydrogen than in air. This is shown by connecting a Bunsen burner with one pipe of an induction coil and gradually raising the other above it until the opening is too great for the sparks to bridge. Upon turning on the gas, the flow of sparks will recommence. If the burner be surrounded with a wire netting, the gas will burn only on the outside. The experiments with the model balloons and a large induction coil showed that when the sparks passed beneath the open filling tube of the balloon, ignition sometimes followed, but where protected by a wire netting, a flaming arc playing upon the netting for a minute did not light the gas.

Wireless on the Zeppelins. In regard to the employment of wireless telegraphy on the Zeppelin type of the present form—an arrangement of the aerial which would minimize the danger of ignition and would also furnish the best electrical conditions for the transmission of signals is suggested; as the hull of the Zeppelin is traversed by a vertical shaft or well, it is possible to support the aerial by a simple Eddy kite, which would be kept aloft by the motion of the airship. The wireless apparatus, including the dynamo, would be housed in the middle of the runway which connects the two cars. The kite would be connected with the apparatus by a wire from 600 to 1,200 feet in length, *i.e.*, one-fourth to one-fifth the length of the electric waves employed. A second wire of the same length and carrying a weight at its end would hang downward from the apparatus and would be kept as nearly vertical as possible by insulated stay or guy lines attached to the cars. The lower wire might, however, be replaced by a fan-shaped antenna about 200 feet long, attached to the frame of the airship and projecting about 30 feet below the hull. With this arrangement communication would be possible even when the ship was flying low. Fouling of the propellers would have to be guarded against by enclosing them in wire baskets or housings.

The **T**-shaped antenna which is carried by ships using the Telefunken system, could also be applied without difficulty to the Zeppelin airship, as the metal frame is abundantly able to carry a light, hollow mast about 30 feet high, which could be raised and lowered by ropes. The stability of the airship, however, would be affected more by this complicated device than by the kite. Experiments have shown conclusively the great promise of the use of wireless telegraphy on airships, but an indispensable prerequisite to its adoption would appear to be the electro-technical development of means of protection from all danger of injury through the working of the apparatus itself, or from atmospheric electricity.

WIRELESS ON AEROPLANES

Owing to its far greater speed and radius of action as well as its more general availability, the employment of wireless telegraphy on the aeroplane holds far more promise for military use. With experience in taking observations from a height, it will become possible to plot maps, note the character of emplacements, and the position of troops from an altitude that would make danger from shell fire from below out of the question. To be of any value, the dirigible must be so large as to make this impossible.

First Message. To James McCurdy, one of the Curtiss school aviators, belongs the distinction of having been the first to communicate by wireless from an aeroplane to a land station. This was on August 27, 1910, when he sent the following message from a Curtiss biplane:

Over Barren Island, N. Y., 6:45 P. M., Aug. 27, '10.
To H. M. Horton:
Another chapter in aerial achievement is recorded in the sending of this wireless message from an aeroplane in flight. McCURDY.

Horton was the wireless operator on the roof of the Sheepshead Bay race-track grand stand, two or three miles distant from Barren Island, though the distance was probably less in an airline. The apparatus was an ingenious makeshift merely intended for the purpose of sending and was not capable of receiving a message. It was extremely compact, the complete outfit, with the exception of the battery, being attached to the steering wheel of the aeroplane. The battery was carried in the aviator's vest pocket, while the aerial consisted of 50 feet of ordinary wire held straight by a small lead weight, the whole trailing after the machine in flight. Such an outfit naturally had but a very limited range, probably not more than five miles, owing to the small amount of energy available, and would be subject to destructive interference from the waves sent out by more powerful stations in its vicinity. It was intended only to demonstrate the possibility of communicating with an aeroplane in flight.

Owing to the high speed at which an aeronautic motor runs, however, it would be practical to carry a very compact alternating generator which would weigh very little and still give the aeroplane sending station a comparatively wide radius of action—doubtless up to 100 miles or more, due to the greater facility with which the electromagnetic waves can be transmitted from a height. The remainder of the apparatus could likewise be made in very compact and durable form, so that there would appear to be no "wireless problem" where the aeroplane is concerned—it is merely a matter of designing instruments for the purpose.

Horton's Experiments. The question of equipping the aeroplane with a suitable aerial that would be effective without being an encumbrance, as well as the fact that a very substantial percentage of the energy emitted by the sending apparatus was absorbed by the numerous guy wires which also acted as a shield to the antennas, appeared to present a difficult obstacle at first. Both, however, have been overcome by a very simple expedient, that of employing the guy wires themselves as the antennas. After experimenting for a long while with numerous different methods of stringing separate antennas, H. M. Horton hit upon the idea of using the wires for this purpose, while the motor is utilized as a ground. Experiments which were made with a machine thus equipped and located in the building of the United States Aeronautical Reserve in New York City proved most successful. Messages were received from various stations throughout the city and even from ships at sea, despite the fact that the aeroplane was located on the first floor of the building and was not connected with any form of antenna protruding above the roof. A very light equipment was used, the total weight not exceeding 65 pounds, although a 6-inch spark coil was employed. Energy was derived from a 12-volt storage battery with a 50-ampere-hour capacity, the six cells weighing but 40 pounds. The guy wires were connected in series and gave a total length of 800 feet on the machine in question. However, the employment of a storage battery in this connection can be considered only as a temporary expedient in view of the obvious limitations of such a source of energy.

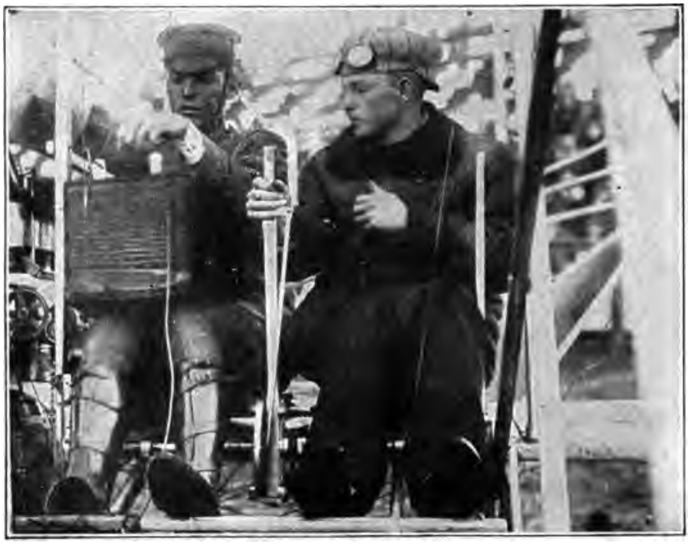

Fig. 54. Parmalee and Lieutenant Beck in a Wright Biplane, Operating a Wireless Outfit

For extended practical use, a generator would be necessary. As the required power is right at hand, this could take the form of a small high-frequency alternator, and as this could be wound for a high voltage, the weight of the transformer necessary could be correspondingly reduced.

Recent Records. *Lorraine.* Numerous other experimenters have been at work with wireless during the past year or so, Robert Lorraine, in England, having succeeded in maintaining perfect communication from his aeroplane with a land station more than *a mile distant.*

Beck. The most practical results, however, were those of the trials carried out during the course of the aviation meet at San Francisco in January, 1911. Lieutenant Paul W. Beck of the United States Signal Corps went aloft in a Wright biplane piloted by Parmalee, Fig. 54, and transmitted wireless messages for a considerable distance while at a height of 1,000 feet. These messages were received at the Mare Island Navy Yard, 40 miles away, as well as at the Yerba Buena Island training school in San Francisco Bay. In Lieutenant Beck's experiments a 100-foot length of copper wire was trailed along behind the aeroplane. In France, wireless messages have been successfully transmitted 15 miles from an aeroplane; while in England, during a trip of the military dirigible Beta, communication was established with headquarters 30 miles distant.

McCurdy. During the Bridgeport, Connecticut, Aviation Meet in May, 1911, McCurdy set a new long-distance mark in wireless communication from an aeroplane by sending messages to the operator in the dome of the World Building in New York City, 55 miles distant, while a number of other stations within a shorter radius also picked up his messages. The apparatus was constructed for the *New York World* in three days by Oscar Roesen, an electrical engineering student at Stevens, and was probably the first set capable of both sending and receiving that has been mounted on an aeroplane. The transmitter consisted of a 4-inch induction coil of the ordinary vibrating type, supplied with current by 15 dry cells connected in series, thus giving a voltage of 22.5, while the amperage was high. The helix was a wood frame 5 inches in diameter and wound with 12 turns of No. 6 B & S gauge aluminum wire, while the condenser consisted of copper plates with a special insulating material as the dielectric. An ordinary telegraph key was employed. The receiver comprised a mineral detector, two straight tuning coils, and a pair of 2,000-ohm head phones. The aerial consisted of a series of wire strung forward from the tail on either side to points directly above the ailerons at the ends of the upper plane of the Curtiss machine, Fig. 55. For a ground, or rather for a balancing aerial, the motor supplemented by wires carried out in either direction to the ends of the main plane was employed. The apparatus proper was mounted in a small box carried below the aviator on the skids of the machine, while the sending key was placed on the steering wheel. The arrangement is plainly illustrated by the accompanying sketch, Fig. 56. *A* is the box, *B* the key, dotted lines *C* the ground or balancing aerial, and full lines *CC* the aerial proper, the smaller sketch below showing how this was wired up. The weight of the complete outfit was between 40 and 50 pounds. Lieutenant Fickel, U. S. A., detailed by the War Department to attend the meet, was very much impressed with the set and sent a complete description of it to the Signal Corps at Washington. Experiments were first made on a Saturday and while McCurdy's signals were plainly heard at the temporary receiving station on the field, the

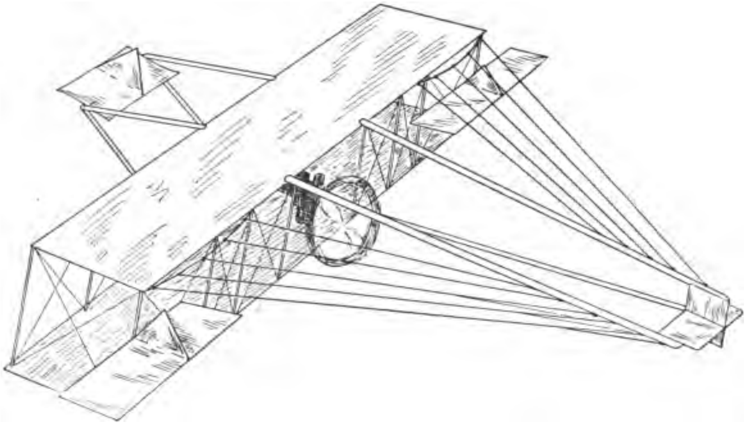

Fig. 55. Diagram Showing Method of Making an Aerial on a Biplane

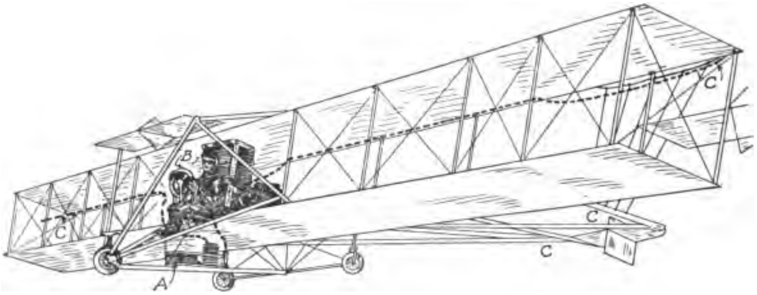

Fig. 56. Diagram Showing Location of Circuits and Equipment of a Wireless Outfit

interference of numerous adjacent stations made it impossible for the operator in New York to pick them up. On the following day there was an absence of interference, and the messages were plainly heard in New York on three different trials, thus establishing a new distance record for aeroplane work, and this is of even greater importance in having reached the heart of the metropolis, as New York City is generally conceded to have many adverse elements for successful wireless reception from outside points, chiefly due to the great number of high, steel-frame buildings. Tests made of the receiving abilities of the set showed it to be capable of picking up messages from a distance of 200 miles, but unfortunately no trials of this nature were carried out in the air.

General Problems. It will be apparent from the foregoing that all of the experiments made thus far have been in transmitting messages from an aeroplane in flight, and while this is a very valuable accomplishment, receiving is quite as necessary, to take complete advantage of the value of the wireless as a means of communication, and for reasons that are obvious this does present more of a problem than the mere sending of messages.

Eliminating Noise. The chief difficulty is that of noise, as with the unmuffled motors now generally in use, it is practically impossible for two men sitting side by side in an aeroplane to carry on a conversation. This is further complicated by the rush of the wind and the high pitched note occasioned by the vibration of the numerous guy wires and struts, but with close-fitting, double-head receivers, there should be no difficulty in shutting out practically everything but the noise of the motor. The matter of expediency that has been responsible for the adoption of so many of the makeshift features of design that characterize the present-day aeroplane, and probably will continue at least for a few years to come, has likewise been responsible for the elimination of the muffler on the motor. But even now, design and construction have advanced to a point where there is really no necessity for longer doing without this essential, as both the muffler and its connecting pipe can readily be made of aluminum, though, for that matter, the weight of the standard type as employed on the automobile would not form any very serious drawback. Considerably more difficulty would be encountered in muffling motors of the rotary type, but they need it least, as the explosions of a seven- or fourteen-cylinder Gnome motor running at full speed overlap to a degree that converts the exhaust into a loud buzz, rather than the disagreeable and ear-cracking rapid-fire bang of the four- or six-cylinder vertical motor.

Use of Visible Signals. Should the usual audible method of receiving not prove practical, two alternatives are open, both involving the use of a visible signal. In one, a coherer could be connected with a tuning condenser shunted across it, the former being automatically decohered every two seconds by a striker actuated by a magnet excited by a clockwork contact maker. A relay and battery are connected in series with the coherer, and the local circuit of the relay is connected with another battery and small incandescent lamp. Each time a signal is received the lamp would light—one second for a dot and two seconds for a dash. These long signals are obviously necessary, but in spite of that a message could be received with reasonable rapidity. The second alternative is that of employing an inker, this method also involving the use of a coherer. The inking apparatus, however, is not only comparatively heavy, but in order to work satisfactorily, requires fairly close adjustment, so that it would not be suitable for use where there is much vibration —the question of vibration is probably the most serious element of the problem. The coherer is not a particularly sensitive receiver of the weak impulses which have to be caught, and has long since been practically abandoned in wireless practice. But even if it were sufficiently sensitive for such use, it would probably be impossible to make the coherer work long enough to start the local side of the relay working effectively, particularly if the mechanical decohesion had to be rapid. In fact, the actual number of impulses per second of a four-cylinder, two-cycle engine, or a six-cylinder, four-cycle, or any of the rotary motors, is too great to permit a coherer to act, while a coherer insensitive to the abruptness of the shock would not be sensitive enough to respond to the wireless impulses. Either the mineral or the electrolytic type of detector is far more sensitive, but as its adjustment must be delicate to work effectively, it would also be placed at a serious disadvantage by the vibration.

Forms of Aerial. The question of the most practical form of aerial to employ is another difficulty that affects both sending and receiving. The use of a long trailing wire, as well as the employment of the network of guys and braces, has already been referred to in connection with experiments carried out by McCurdy and American army officers. Trailing wires present so many sources of danger to a machine traveling at high speed, that few pilots would care to consent to their use, while connecting up the bracing of the aeroplane is equally impracticable as every piece of metal on the machine then becomes charged, and in sending, serious shocks might be received by the pilot or his passenger. Farman has employed two trailing wires, each about 400 feet long, and Baker has adapted a similar arrangement to a Bristol biplane in England, the wires, however, not being allowed to hang loose in the latter case, thus limiting their capacity. Instead of using balanced aerials, as in the McCurdy experiments described above, he coupled them to each end of an inductance coil, thus increasing their effective length to the greatest extent possible without sacrificing their efficiency. The apparatus consisted of a 6-inch induction coil with a $\frac{5}{8}$-inch spark gap located as far away from the gasoline tank as possible. Two light brass rods extended from the coil well into the space between the two main planes of the machine and to one side of the tank, and two $\frac{3}{8}$-inch rods sliding on these and with their ends separated by $\frac{5}{8}$ inch, formed the spark gap terminals. Shunted across the spark gap was a condenser of the Leyden jar type, and an inductance coil consisting of seven turns of No. 14 copper wire wound on a light ebonite drum. This inductance had sliding contacts so that the number of turns used could be varied in the usual manner, in order to tune the two circuits. The two aerial wires were connected to the two ends of the inductance in use and the aerial circuit was brought into tune with the shunt circuit. A storage battery of five cells supplied the necessary energy, about 50 to 60 watts being required. Two new arrangements which should greatly increase the efficiency of the apparatus have since been adopted. The more important of these is a long, light brass tube attached to the tail of the aeroplane but insulated from it. This acts as counter-capacity or "ground" to a long aerial wire on the other side. This aerial starts from the nose of the machine, and is carried thence to the extreme outer edge of the main plane, back to the tail, and from this to a loose connection, 60 feet of copper wire trailing behind.

Possible Developments. It is evident that these isolated experiments, while more or less numerous, are but the beginning of the serious study that will be given the matter within the next year or so. Nine-hour, non-stop flights covering more than 400 miles give some idea of what will be accomplished in the way of long-distance flying in the near future—in fact, they make the possibility of being able to cover more than 1,000 miles per day of twenty-four hours seem very close at hand, so that Atwood's proposal to fly across the Atlantic in three days appears to be only a question of carrying sufficient fuel. To be able to keep in constant communication with these long-distance flyers would be invaluable, and that is what experimenters in the wireless field aim to accomplish.

Wireless telegraphy from the dirigible has already reached a more advanced stage, as neither the use of a trailing wire nor the matter of weight present such serious disadvantages as on the aeroplane. The apparatus used on the British military dirigible Beta weighed approximately 100 pounds, and as signals have been sent 50 miles under favorable conditions, the proportion of weight to distance of transmission was, roughly speaking, 2 pounds. But an ordinary induction coil and accumulator were employed, so that this can scarcely be taken as a criterion. They were used in connection with a trailing aerial and a counter-capacity, and, as the chief requirement of the latter is superficial area to take the charge, as light a substance as possible, such as paper-thin sheet aluminum, could be employed.

The form of the wireless installation suggested by one of the chief English experimenters as best adapted to the needs of the airship is that of a small auxiliary motor, say, a two-cylinder, 3- to 4-horse-power machine, directly coupled to an alternating generator of about 2 kilowatts capacity, together with an aerial about 350 feet long, and a counter-capacity in the form of very thin metallic sheeting, suitably disposed. Considerable attention is now being given to the production of portable apparatus. The chief limiting factor in connection with small receivers naturally has to do with the detector, the vacuum valve type of Professor J. A. Fleming probably being the most suitable in many respects, and next to that an electrolytic detector.

Akron Outfit. The new dirigible Akron, in which Melvin Vaniman is to make his second attempt at crossing the Atlantic, is a forcible example of the careful attention now being given to wireless equipment and the dependence placed upon it as a safeguard. Vaniman, it will be recalled, was Wellman's chief engineer on the America, and he has taken advantage of that experience to embody all the improvements in the new equipment that were found lacking in the America's set. The latter had a sending range of only 80 to 90 miles, so that while the operator could catch the numerous inquiries that filled the air regarding the America's whereabouts during the 48 hours or more that it was out of sending range, he could not reply to any of them. The equipment of the Akron is a Marconi set with a sending range of 700 to 800 miles and consists of a 3-kilowatt, 120-cycle, alternating-current generator, direct driven by a 17-horse-power, 4-cylinder gasoline engine. For receiving, the most advanced type of musical, rotary spark gap and a valve detector will be employed. As a counter-capacity does not permit of the most efficient operation, a flexible, phosphor bronze wire trailing in the water will constitute the ground, the equilibrator which was used for that purpose on the America having been abandoned. This trailing ground is wound on a drum and sufficient wire is provided to reach the water at any point from 100 to 1,200 feet elevation, the amount played out depending upon the height at which the airship is flying. However, should the airship rise higher, provision has been made to operate the equipment as an unbalanced Hertz oscillator without a ground. The transmitter is of the loose-coupled type and is so arranged that considerable variation in the natural period of the open oscillating circuit will have a minimum effect upon the transmitted signals. The frame of the envelope is used as one side of the oscillator, the trailing ground acting as the other. Particular care has been taken in the design of the various parts of the apparatus to prevent any possibility of a spark from the high-tension apparatus igniting the hydrogen gas. Jack Irwin, whose call of distress from the America brought the S. S. Trent to their rescue, will accompany the Akron as operator.

EXAMINATION PAPER

AERONAUTICAL PRACTICE

PART II

Read Carefully: Place your name and full address at the head of the paper. Any cheap, light paper like the sample previously sent you may be used. Do not crowd your work, but arrange it neatly and legibly. *Do not copy the answers from the Instruction Paper; use your own words, so that we may be sure you understand the subject.*

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1. What was the chief question at issue between the Wright Brothers and the Curtiss Company in regard to patent infringement?
2. What steps have been taken in France in regard to legislation?
3. Consider the justice of the grounds on which the Wright patents were partially invalidated by a decision in Germany early in 1912.
4. Outline briefly the importance of aerial crafts for military purposes.
5. Describe Ely's flight to and from the U. S. S. "Pennsylvania."
6. What dangers are encountered in using wireless telegraphy on aerial craft?
7. What precautions may be taken against these dangers?
8. Describe Horton's wireless experiments.
9. How was the wireless apparatus of McCurdy constructed?
10. Make a diagram of obtaining an aerial on a biplane.
11. With what problems are we confronted in receiving wireless messages on aeroplanes?
12. Describe Baker's wireless outfit.
13. What sending range has Vaniman's wireless?
14. Describe the military aeroplane tests in France and their outcome.
15. What are the advantages of a hydroaeroplane in connection with military operations?

16. What suggestion has been made in regard to the employment of wireless telegraphy on the Zeppelin?

17. Why would it be practically impossible to use any guns successfully in defense against aeroplanes?

18. Discuss bomb-dropping from an aeroplane as to accuracy and destructive effects.

After completing the work, add and sign the following statement:

I hereby certify that the above work is entirely my own.
(Signed)

APR 11 1917